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BABY WELFARE:

A GUIDE TO ITS ACQUISITION AND MAINTENANCE . . . By

W. E. ROBINSON, M.D., B.Ch., B.A.Oxon., &c.

Assistant Physician and Pathologist to Infants' Hospital, London

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PREFACE

THE importance of infant welfare to the nation at the present time cannot be over-estimated, and furnishes me with an excuse for publishing in book form the substance of lectures delivered by me at the Infants' Hospital, Vincent Square. A further reason I find in the many requests I have received from my own patients for some book which will enable them to correctly manage their infants. An untrained nurse and a newly-made mother are in much the same position towards an infant, and in seeking how best to educate these two minds to a knowledge of their subject, it has seemed to me that the only method to employ must embrace a brief survey of the physiology of the infant. It is a closed book to the average woman, and yet it is vitally important that she should have a clear grasp of the elements at least of this subject.

Consequently the first part of this work deals with anatomy and physiology; the second part with the physical and chemical properties of milk, together with an introduction to the study of bacteriology. From this it becomes an easy matter to pass on to the adaptation of milk to the physiological requirements of the child; and lastly, to appreciate the many ailments of infants dependent upon errors of diet, so that by the avoidance of these errors a large proportion of infant mortality may be avoided.

Professor Holt and Dr. Ralph Vincent, Professor E. H. Starling and Dr. Lazarus-Barlow are the authorities upon whom I have very largely drawn. I have also to acknowledge valuable hints from friends, as Mr. H. Tyrrell Gray and Dr. Frew.

It must be remembered that these chapters were originally given as lectures to young nurses absolutely ignorant of any anatomy or physiology, and that therefore the language is as simple and unscientific as possible. The teaching, however, is based on the well-known scientific writings of the above-named, and consequently all that is found in this volume can be studied at further length in the originals.

In an appendix I have sketched the requirements necessary to a pure milk supply, and as well have added various formulæ of modified cow's milk. This latter, not so much for general use as to instruct the mother or nurse how to accommodate cow's milk to the requirements of her infant.

W. E. ROBINSON.

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INTRODUCTION

A STEAM engine and a baby are among the commonest objects met with in our everyday life. We accept them as a matter of course. Their outward appearance is so familiar that we do not concern ourselves with the complexity of their internal mechanism. Provided that they are well behaved, we do not begin to inquire into the nature of their component parts nor into the processes by which these carry on their functions. It is only when a breakdown occurs that we are brought face to face with the consciousness of our limitations. For no one, without previous instruction, is able to correctly locate, still less repair, the defect which has caused a breakdown in an engine. Indeed, it is not necessary to wait for a breakdown of the engine before we are convinced of our ignorance. Imagine, for a moment, the engine-driver is indisposed; is unable to continue to drive his engine. Can anyone of us without previous training be expected to be able to take the place of the driver? The answer surely is in the negative, the assumption is too absurd.

And yet a young mother is in exactly the same position towards her newly-born infant as this imaginary amateur driver would be towards his engine.

Instinct teaches her to feed the infant with the food which Nature has provided. Her own consciousness of cold and heat suggests the need for suitable clothing, and the sense of comfort acquired by her will cause her to keep the body clean. But beyond this there is nothing. If left to her own knowledge or want of knowledge, she would assume that every cry of the infant meant hunger, and would endeavour to supply food at all times, regardless of the laws of physiology. Indeed, the reckless feeding of infants at irregular hours is responsible for a good deal of the ailments seen in young infants.

It is this utter ignorance displayed by mothers of the most elementary laws of physiology which has suggested to me the need for a short account of these as a preparation for the study of infant feeding and management.

For surely as an engine-driver must pass through the workshops before he can properly understand his engine, so the mother should learn the various organs of the infant's body and their position—that is to say, the infant's anatomy, together with the normal processes that go on in their organs, or, in other words, the physiology.

By closely studying the following pages then, the reader will obtain a knowledge of the infant's anatomy and physiology. After this, the characteristics of Nature's food for the infant will be outlined and noted, so that the adaptation of these to the normal physiological requirements of the infant will be readily understood. Following upon this the reader will learn the history and course of the common ailments to which the infant is liable, and fortified with the knowledge thus obtained, be in a position, as the engine-driver towards his engine, to undertake the management of an infant.

In this way, and in this way alone, can we be truly said to be studying the infant's welfare. It may be tedious, but I know of no other method by which a mother can be fitted to have the care of her infant.

Nothing is ever gained without some effort, least of all can knowledge be acquired without working for it. There is no short road to knowledge, and without knowledge on the part of mother and nurse our infants are at the mercy of every chance friend who may call and advise some unjustifiable line of treatment. For it is every mother's experience to have gratuitous advice thrust upon her at every turn. At one time she should do this, at another that, until she is in a state of utter bewilderment. This state of things would be amusing if it were not bound up with so important a subject as the life of a newly-born human being. As it is, it is little short of a tragedy in very many instances, and could be so easily avoided by the possession of the necessary knowledge which can be obtained by a perusal of these pages.

Let us then commence our studies by drawing a picture of the infant and its life during the first two years from birth.

PART I

THE HEALTHY INFANT

MAN is a warm-blooded animal, having a body temperature of about 98·4° Fahrenheit. His requirements to support life are food consisting of carbon and nitrogen, which he derives from a mixed diet of flesh and vegetable and water; oxygen to breathe which he draws from the air, and sleep during which his energies are recuperated. Unlike the other warm-blooded animals, he is not clad with fur; he therefore needs clothing to protect his body from injury, and to help to maintain him at an equal temperature.

The infant, man's offspring, is warm-blooded like his parent, and his requirements for the carrying on of life are similar:—

Carbon,
Nitrogen,
Oxygen,
Sleep,
Warmth.

In all warm-blooded animals Nature provides that the offspring shall derive suitable nourishment from its mother, who secretes by means of her breasts a fluid known as milk, which contains the elements carbon and nitrogen in a state requiring little or no digestion. For it must be remembered that as the infant is nothing like an adult in the development of its muscles, bones, intellect or stature, so its digestive organs are not at first fully developed; there has to be a gradual building up of a digestive apparatus capable of dealing with the various food-stuffs which make up the ordinary mixed diet of the adult.

At birth the infant is of a bright pink or red colour. This bright red colour fades gradually, so that in about fourteen days the skin is white with a peculiar pink tint, this colour lasting for about nine or ten months, when the rosy cheeks characteristic of a healthy infant begin to appear. The skin is of exceedingly soft and delicate texture, covered in the hairy parts—scalp and back—with a fleecy down. This first hair is usually dark, somewhat woolly, and does not remain permanently. It is shed in from three to four months, and then the real hair slowly makes its appearance.

For the first twenty-four hours after birth the infant sleeps continuously. Sooner or later its need for food becomes insistent, and having no powers of speech to ask for this, it makes its requirements known by crying. The healthy baby should wake regularly for its feeds at intervals of two hours. Up to three months of age this interval should be maintained during the day; but at night it usually can be prolonged to four hours.

After three months the infant is able to take a larger amount into its stomach, and as a result the interval between feeds is lengthened to two and a half hours, at six months to three hours. When nine months old the healthy infant should be weaned from the breast and given cow's milk with water;

in addition, it requires starchy food, as we shall see when we come to the physiology of digestion.

The dejecta—urine and fæces—form an important index to the health of the infant.

During the first twenty-four hours after birth the fæces are black, not unlike tar in consistence and colour. This black stool is known by the name of meconium, and represents the debris collected in the intestinal tract prior to birth.

After twenty-four hours this meconium is expelled and the stools become bright yellow, having the appearance in consistence and colour of mustard as used at table.

The number of stools during the twenty-four hours should be at first four or five; gradually, as the infant grows older, this number is reduced to two or three; from three months of age the stools should be at least one, but two or three a day is a desirable number. The consistence up to nine months of age should be still semi-solid or pasty, the colour yellow, no offensive smell, and no "curd" or white pips which indicate non-digestion of some part of the infant's diet.

The urine is a clear amber-coloured fluid, neutral or slightly acid in reaction and free from odour. As the infant grows the urine becomes frequently very acid, although the health is good, but normally after three months the reaction should be moderately acid —clear, and with only a faint characteristic smell.

It, as well as the fæces, is voided incontinently at first. Yet at the end of the first month of its existence it is quite common to find the infant cleanly and regular in its habits. This is entirely owing to the care and watchfulness of a good maternity nurse, who quickly learns the signals given by the infant expressing discomfort and desire to pass urine or fæces. The habit of regularly passing stools should be inculcated as early as possible; as early as nine months of age, but certainly by twelve months, the infant should be absolutely clean in its habits. This, as I have said, entirely depends upon the nurse or mother.

Sleep for the first three months of the infant's life may be said to be practically continuous throughout the twenty-four hours, only being broken by the need for food at regular intervals of two hours and, of course, by attention to its toilet. Sleep after a feed is the rule. Between the third and fourth months the signs of a dawning intelligence appear; the infant begins to notice objects such as the ribbons of its cot; it lies awake in the day, in cot or nurse's arms, during part of the interval between feeds.

By six months the intelligence has so far developed that bright objects are attractive to the infant; it grasps these in its hands, plays with them, and makes strenuous efforts to raise itself into the sitting posture, sleeping less regularly between feeds, so that by nine months definite portions of the day are given up to wakefulness; but still there are periods of sleep during the day, whilst at night there is the long period of unbroken sleep. Up to six months of age, one or two feeds have to be given at night; after this period a healthy infant will sleep throughout the night—that is, from 10 p.m. to 6 a.m., only waking for the passage of urine or fæces.

It is important to remember that the infant that has learnt cleanly ways is in real distress in the night if the nurse or mother is inattentive to its cries. Many a child learns dirty habits of uncontrolled bladder solely because its nurse or mother fails to awake and pick it up when first it gives notice of its requirements.

Teeth, the first trouble of a healthy infant, begin to appear after six months. This is not a fixed time; many infants show teeth at an abnormally tender age, three or four months; and again, many do not show any signs of teeth until after eight months; these late infants are curiously the most healthy and sturdy.

Still, it may be taken that at seven months the infant has cut its first tooth. There is a definite order in which the teeth should appear—namely, the two middle incisors of the lower jaw, then the corresponding two in the upper jaw. After an interval the two remaining lower and then the upper are cut, so that at the end of the first year eight teeth are visible, four in the lower jaw, four in the upper—all in front.

After the incisor teeth four molars make their appearance, two in each jaw. These teeth are not immediately next to the incisor teeth, but separated by a gap on each side of them, which is later filled by the canine, so that each half of the jaw, starting from the divisions between the middle incisors and tracing backwards, shows two incisors, one canine, and one molar. These have all appeared by the end of the second year. Then follow the four remaining molars, making the complete set of temporary teeth at about 2½ years of age, these temporary teeth remaining until the seventh year, when they are replaced by the permanent set.

The first sign of teething is salivation. For some time before the jaws show any fulness the infant begins to drool saliva; this becomes more pronounced as the tooth comes nearer the surface, and at this time pain is experienced, evidenced by the infant frequently crying out in its sleep, flushed cheeks, and irritability when awake. Some feverishness is usually present, and, as well, irregular action of the bowels—possibly diarrhœa, a slight nasal discharge, and even some bronchitis with cough.

It is a natural process lasting only a few days, and requires in the healthy infant little attention. A point to remember is, that the infant that is correctly fed seldom experiences any trouble in cutting teeth.

Muscular development begins to show itself at about the end of the third month. At first the infant is extremely flabby, hence the young mother's fear lest she should drop the infant when first she learns to handle it. The head, by reason of its weight, is inclined to fall from side to side. One should then when picking up a baby take care that a supporting hand and arm are placed under the head. By the fourth month the head is supported by the proper muscles, although it should never be forgotten that there is danger in picking up an infant quickly so that the head is thrown violently backwards. The explanation of this is that the skull is supported on a sort of pivot, the uppermost part of the vertebral column. This pivot may easily be forced backwards, causing pressure on the spinal cord, which is the communicating link between the brain and the vital organs. Cases are on record in which the sudden picking up of a baby has thrown the head violently backwards, causing dislocation of this pivot, followed by instantaneous death. Exactly the same thing happens in hanging; the subject who dies from hanging has his neck broken in precisely the same way. No one then should forget in picking up a baby to place the hand under the head to prevent this calamity.

We have seen so far that our infant develops as any animal—it eats and sleeps, passes a certain amount of excreta daily. But it is warm-blooded—that is, has a normal body temperature of 98·4° F., which is considerably higher than the atmospheric temperature. How is this temperature maintained? By suitable food is the answer. But as well by properly adjusted clothing; otherwise, the heat generated by food would be lost by contact with the cooler atmosphere. A most important duty of the nurse is to regulate the amount of clothing to the changes of our climate. And I think that, as a rule, this is well and intelligently done.

The main thing to remember is comfort, together with warmth and lightness. For a newly-born infant the day garments should be, first, a flannel binder round the abdomen, 2½ in. wide and about 1 yard in length; next, a soft woollen or silk and woollen vest with long sleeves. Over this the ordinary "long" flannel, and then the day gown or dress surmounted by the head flannel or shawl. At night the binder and vest are retained, and over these is a nightgown of flannel or cotton. In addition, all young infants should wear woollen socks.

Unless the weather be very hot, the flannel binder or a Jaeger cummerbund should always be worn up to at least six months of age or even a few months older.

Much must be left to the discretion of the nurse or mother, but the important point to remember is that warmth is vital to the comfort of the infant. Those delicate infants which never seem to keep warm want extra clothing, and even strong infants insufficiently clad are certain to have digestive disturbances and to be fretful and exhibit signs of colic.

In older children warm feet are essential to their well-being when out of doors; so that in cold weather they should not be allowed to go out with bare legs, but should be supplied with gaiters.

The shoes require care in their selection, for older children especially. They should be of the shape of the foot, broad and roomy, allowing for the toes to expand into the front of the shoe on walking. The soles should be moderately thick; it is a great mistake to let a child wear shoes which have thin flimsy soles.

In addition to paying attention to the clothes, one must remember the nursery. The day nursery should be sunny and airy; in the winter there should always be an open fire protected by a guard. The temperature of the room should be from 55°—65° F., and the room ventilated by opening the bottom and the top of the window.

Let us consider what actually takes place in the air. Cold air is heavier than warm air. The warm air tends to ascend, and it is this warm air which must be got rid of, for it contains the waste products of respiration from the inmates of the room. If only the bottom of the window is opened the warm, vitiated air cannot get out: therefore it should be a rule to open the top of the window for this bad air to escape, and the bottom for pure fresh air to come in. The night nursery should be warm in cold weather. There should be ventilation through the top of the window, but the child's cot should be screened from any draught.

At night time there should be great care in regulating the body temperature of the infant. Often I have seen babies sweltering under too many blankets, purely because the nurse, having failed to realize that the night has turned suddenly hot, has not altered the amount of clothing to suit this change. For young infants a flannel nightgown with one or, at most, two blankets over is all that is required. When the infant is one year or older a combination night suit of flannel is the most suitable garment.

The posture of the sleeping babe is interesting. In quite young infants one side is usually preferred to the other to lie on. It is, however, useful for the nurse to learn to change the infant on to the other side; it is often successful in getting the infant to sleep again, should it wake before feeding time, and should be adopted at each feed.

An interesting point I have observed in all young animals is that they tend to sleep curled up with their noses tucked in under cover. Infants are no exception to this rule. They tend to burrow their noses under the bedclothes, and for my part I do not see why they should not do this. My own teaching is not to disturb the sleeping healthy babe;

it assumes naturally the posture most comfortable to itself. Often this is the prone position, and if the pillow is low, it is perfectly safe to allow it to remain in this posture.

A point to remember in the matter of sleeping infants is the care with which they should be picked up. All infants are very nervous, and if disturbed thoughtlessly or violently by a nurse a nervous disposition can readily be made worse; therefore a nurse, going to pick up a child from a cot, should be very careful to pick it up slowly and quietly.

After the third month there is steady development of muscular power.

At the age of four months the infant will tend to grasp things, though as yet in quite a purposeless fashion. Bright objects such as tea-spoons appear to interest them more than anything else. Then comes waving of the arms and legs. These movements should not be controlled by the nurse, for muscular effort means interchange in the body tissues of food and waste products. The products of digestion are brought to the muscular tissues, and used up in the metabolism of the body to create a storehouse from which the infant's growth is derived. The arms and legs, therefore, should be as free as possible, and any nurse will agree that the most fractious infant is happy when allowed to lie and kick freely. It is a good practice for the nurse to place her charge, before the evening bath, on a pillow or rug on the floor in front of a fire for a good kick before bedtime.

Sitting up commences at about eight months; the infant has by this time become purposive in its movements of hands, and sits up and plays with its toys; about two months later it learns to crawl, and at about thirteen months, or maybe even at one year, it pulls itself up by means of the furniture and learns to stand. From this time on it gets its walking legs, and gradually leaves behind its crawling habits, to the very great comfort of its nurse.

Speech develops slowly. At quite an early age—four months about—the infant croons to itself. A little later it begins to imitate sounds of words, and at about nine months it learns to respond with such words as "ta," "dada," and "mama." In many babes, and especially where there are other children in the nursery, stringing together of words begins at about thirteen months. Where there is but one child, however, this stringing together of words is postponed to sixteen or eighteen months, or even later. This point should be noted, because anxious parents are often worried that their baby does not talk. It is natural to associate backwardness in talking with backwardness in intellect, but in the case of a single infant it is quite common to find speech delayed until late in the second year, although the intellectual development is good.

Indeed, I have known babies up to 3 years of age who have not made an effort to talk, although it was clear that they were intelligent and understood all that was said to them.

To complete our knowledge of the development of the infant, we should know the average length and weight at respective ages.

At birth, length is usually 21 in.; there is not much increase for two or three months, but after this growth is steadily progressive, until at twelve months length is about 30 in.; at two years about 36 in. The weight may be taken as somewhere about 8 lb. at birth. During the first few days there is a loss of weight, but by the end of the first week this loss is regained, and thence afterwards the weekly gain is 6 or 7 oz., so that at six months the weight is double that at birth, and it is trebled at twelve months of age.

We have by this piecemeal analysis fashioned in our mind's eye a picture of a normal infant, and we should now study more closely the details of the infant's anatomy and physiology.

PART II

THE SYSTEMS

Introductory

In our previous chapter we looked at the normal healthy infant and its life-history during the first two years; we now want to know in greater detail the component parts or organs of the body, and the processes or functions performed by them. We will divide the body then into the following systems or collections of organs:—

The Skeleton.	
The Circulatory System:	(*a*) Blood, heart, blood-vessels (*b*) Lymphatic vessels.
The Respiratory System:	(*a*) Air-passages. (*b*) Lungs.
The Digestive System:	(*a*) Stomach and intestines. (*b*) Glandular organs, liver, pancreas, spleen.
The Excretory System:	(*a*) Skin and lungs. (*b*) Kidneys. (*c*) Colon and rectum.
The Lymphatic System.	
The Central Nervous System:	Brain, cerebrum, cerebellum. Medulla oblongata. Spinal cord. Spinal nerves.

CHAPTER I

THE SKELETON

THE Skeleton consists of, from without, inwards :—

(1) Skin.
(2) Fat.
(3) Muscles.
(4) Bone.
(5) Central and peripheral nervous system.
(6) Blood-vessels : (*a*) Arteries.
  (*b*) Veins.
  (*c*) Lymphatics.

The colour of the skin in healthy infants has already been described. What are the uses of the skin? It is, of course, the outer covering of the body, so one function is that of protection.

In the skin are placed sweat-glands and an intricate network of small blood-vessels and nerves.

Blushing gives a good illustration of these three working together. In response to a stimulation brought by the nerves the blood-vessels dilate; the skin looks red and is actually more full of blood, the sweat-glands are encouraged to work and pour out their contents on the surface of the skin. What is the effect of this "blushing" on the whole body? Clearly a large amount of blood is brought to the surface—it is thereupon cooled by contact with the outside air. Hence we see another function of the skin is to regulate the temperature of the body.

This regulation of the temperature is also increased by the evaporation over the whole surface of the body of the sweat poured out on the surface of the skin. We have seen that blushing produces an increased flow of blood to the skin; the sweat-glands are more vigorous in their action in consequence, and, therefore, more sweat is poured out upon the surface. The amount of evaporation of this sweat naturally depends on the temperature outside the body; rapid evaporation takes place in a hot climate, and so keeps the surface of the skin cooled down. Thus the skin's function of regulating the temperature of the body is performed in two ways: directly by cooling the increased amount of blood flowing in the skin, and by evaporation of sweat poured out upon its surface.

The sweat, however, is not only plain water, it is made up of various elements, some being waste products, brought from the centre of the body, and we therefore see that there is a third function of the skin—namely, that of excretion.

Beneath the skin is a layer of varying thickness of fat. Fat, besides rounding off and so beautifying the figure, is necessary for maintaining the warmth of the body, and it also acts as a storehouse of nourishment from which the individual may draw. This is especially noticeable in fevers and illnesses, when, it may be, no food but only water can be taken by the patient. Life still goes on, and is maintained by using up the fat stored up beneath the surface in the body. It is thus seen that the function of the fat is an important one, and we can readily understand the wasting of an individual during an acute illness, when the food taken by the mouth has been insufficient to satisfy Nature's requirements, and when the illness has been of any duration.

Beneath skin and fat is the muscular layer of the body. The muscles, of course, produce all the movements of the limbs. But it is in the movements of muscles that a great deal of the food brought into the body is eventually used up, so that there is a second important function of the muscles—namely, to act as a manufactory and clearing-house. Food, when digested, passes into the muscles in solution; owing to cell activity chemical change takes place in these food-stuffs; part is utilized by the muscles to keep their vitality and energy, and part is turned out as waste product or excreta. Therefore, we learn to look upon vigorous muscular movements as necessary to the internal economy of our infant, not only for developing its physical power, but also for increasing the digestion of all food taken into the stomach, and using up the products of digestion.

To understand the nature of these chemical changes we must look into the history of cell life. For the skeleton is in reality a collection of cells, differing in their outward appearance according to the function for which they are developed, but each subject to the same laws—passing through the same changes in their internal workings.

To make this clear we will consider the amœba, which consists of but a single cell, and is found in nature living a separate existence. It has an outside wall or shell. This shell is filled with a gelatinous material known as protoplasm, and contains in its interior a central, more highly developed part, known as the cell nucleus.

This cell lives a separate existence—that is to say, it supports itself by sucking in food from its environment through its outer wall into its internal protoplasm, which is able to digest and make use of food thus obtained, throwing out through its cell wall those portions it cannot digest. The life-history of the cell is that it propagates itself by means of division. First the nucleus divides so that the cell contains two nucleoli. Gradually the cell wall falls in, so that eventually each nucleolus is surrounded by a ring of protoplasm and cell wall. Finally, the cell wall subdivides or cleaves in two, and there are two amœbæ, each capable of repeating this life-history.

Now all cells that compose the human body are similarly constituted, taking in nourishment and throwing out waste products; those which form the muscles do this very considerably as part of their function. The question of reproducing themselves need not be discussed. It must be realized that beginning with one cell the human embryo develops by growth of cells, and each layer of the skeleton becomes mapped out by differentiation of these cells, so that one layer forms the skin, another layer forms the fat, another the muscles, and so on. They have all started from one cell, and when they have arrived at their final stage of development they still carry on their cell life similarly to the cell life of the amœba and, as well, perform the special function for which they have been differentiated.

Deep in the muscular layer run the big blood-vessels and nerves, and beneath or internal to this is the bony skeleton. It is necessary to consider certain facts concerning the bones in order to appreciate their functions and dangers attending them.

The bones of our infant are all very soft for the first few years of life. They are originally laid down in cartilage, *i.e.*, a soft gelatinous material. It is only as time goes on that lime salts are deposited, giving to the bone that degree of hardness with which we are familiar, and which is necessary for their special function, that of supporting the soft tissues of the body.

The long bones of the body have a growing point in the centre and also one at each end. These ends are known as epiphyses; they do not unite with the central growing point until the growth of the bone is completed, *i.e.*, about the eighteenth to the twenty-fifth year. If an epiphysis becomes separated from its shaft its blood supply fails and growth ceases, consequently the limb is permanently shortened.

The shaft and epiphysis are both growing, and continue to grow up to the end of about the eighteenth year, but if owing to a break the blood supply is cut off, then this part of the bone cannot continue to grow; as a good deal of the end of the bone grows from the epiphysis, it is clear that there must be shortening due to separation of this epiphysis.

I can now point out one danger. It frequently happens that mothers or nurses drag a child upstairs by one arm, or even help it to learn to walk holding one hand. The child slips—a sudden wrench may separate the epiphysis—and later on a definite shortening of the limb results. It is a simple accident easily brought about. There may be few signs of trouble at the time of injury, but later the shortening of the limb is noticed, and is a serious impediment to the subject.

The tendency of these half-formed bones to bend or even break must ever be borne in mind. I always look with suspicion on a fracture in an infant as pointing to carelessness on the part of the nurse. Genuine accidents may account for many fractures, but a hasty nurse pulling a tiny baby's arm into its clothes may easily, and often does, produce a fracture in the shaft of the long bone.

CHAPTER II

THE CIRCULATORY SYSTEM

CIRCULATION of the blood is the next system for our consideration.

Blood is the vehicle by which every organ or part of the body is supplied with its nourishment and oxygen, and by which the waste products from these organs or parts of the body are removed.

Blood is a sticky or viscid fluid containing two important elements: cells, red and white, known respectively as red and white corpuscles, floating in a clear fluid called serum or blood plasma.

The blood remains fluid in health so long as it is confined to its blood-vessels; when it emerges from these, say by means of a cut, and comes in contact with air, it rapidly clots or coagulates. It is normally an alkaline fluid, and its functions are separated according to its constituent elements. These elements, as I have stated, are the fluid part, the plasma, and the red and white corpuscles. These corpuscles are very minute; the red are many times more numerous than the white, being found in the proportion of 5,000,000 red to 10,000 white cells in each cubic millimetre.

The plasma acts as the carrier of food-stuffs passed into it in solution from the alimentary tract, of oxygen from the outside air through the lungs, and also of waste products from the cells of the body. Its fluid permeates all the tissues of the body: how, we shall see later on.

The red cells have a special affinity for oxygen, which we know is necessary for our existence, and which we derive from the air through our lungs. The red cells, therefore, may be looked upon as having a special function, that of oxygen carriers.

The white cells are the nearest approach we can find in every respect to the amœba, not that they can carry on separate existence outside the blood fluid for long, but in the blood fluid they pass through the same life-history as the amœba; they are capable of taking into their own cell protoplasm particles of food, micro-organisms and so forth, and digesting them in the cell, as the amœba takes in and digests nourishment. They may be looked upon as eating cells or phagocytes. It must not be inferred that all white cells are alike in this respect; but it is important to note that this is a function special to white corpuscles, just as that of oxygen carrying is special to the red.

This blood, then, is ever moving or circulating round and round the body. We can picture to ourselves a continuous tube in the shape of a circle. This tube is filled with fluid, and that fluid is constantly in motion in one direction. Now place somewhere on that circle a pump. The best illustration is the ball pump in the ordinary Higginson's syringe. This pump when closed passes the fluid on in one direction, and one direction only, because there are valves at the inlet and the outlet, one allowing fluid to flow into the ball but not out of the ball pump, the other allowing it to flow out and not in.

Returning to our circle and the pump we have constructed in the human anatomy: it is the heart that is the pump in our circulation. It pumps, and the blood flows out of its substance through blood-vessels known as arteries. The arteries divide and subdivide into smaller and smaller vessels until they reach the organs or tissues of the body. Here they are so finely divided, and so thin in their covering, that the blood-vessels no longer can be said to possess any walls, and they are known as capillaries. Each organ or tissue is thus flooded with blood, which does not remain stationary there, but continues its progress in the capillaries; these form by coalescing another set of tubes or blood-vessels known as veins, and by these veins the blood continues its course on to the heart, thus completing the circuit in one large vessel (the vein) in the same way as it started from the heart in one large vessel (the artery).

The heart is divided into four chambers, two receiving, known as auricles—left and right—and two pumping chambers or ventricles, also left and right.

We must now have double vision of our mind's eye and follow the squeeze or pumping of each ventricle.

They empty themselves synchronously. The blood of the left ventricle flows out to the whole of the body through the main artery, the aorta, into its countless ramifications, ending in capillaries; from these it is re-collected into the veins, and is brought back to the right receiving chamber or auricle. The blood of the right ventricle passes out through its main artery, the pulmonary; divides into capillaries and is distributed to the lungs; thence it is re-collected in veins and brought back into its receiving chamber, the left auricle.

This pump or squeeze of the two ventricles of the heart is known as systole. After systole there is a pause known as diastole, when the two ventricles are filling with blood from their two receiving chambers or auricles. When the ventricles are filled the diastole is over, and the next systole is ready to begin.

It has been seen that, to prevent fluid flowing backwards instead of forwards, this Higginson's syringe is fitted with valves. Exactly the same thing is provided by Nature. To prevent blood being forced back into each auricle during systole, each has a valve guarding the orifice from auricle to ventricle, and to prevent blood flowing backwards from the arteries into the ventricle during diastole the orifice of each artery is guarded by valves. Finally, there is a dividing septum or wall between each ventricle and auricle which prevents intercommunication between these two sets of chambers respectively.

The number of beats of the heart per minute in an infant is about 140 at birth, gradually sinking to 90—100 during the first six months; an adult man normally shows 60 beats to a minute and a woman about 70.

So much, then, for the heart's mechanism.

To enable the reader to understand the circulation it is necessary to divide our original circle up into three sections. These sections or divisions of the circulation are known as:—

(*a*) The systemic circulation.
(*b*) The pulmonary circulation.
(*c*) The portal circulation.

The systemic circulation is that part of the circulatory apparatus that supplies every organ of the body with blood. Starting from the left ventricle of the heart the blood emerges by means of a single large artery, the aorta, and is carried to its smaller and smaller divisions until it is distributed by means of capillaries into every organ; then it passes on returning by means of veins, to be collected into one large vein opening into the right auricle of the heart.

The pulmonary system starts in like manner from the right ventricle of the heart, passes out through the pulmonary artery to the lung, and back again through capillaries and veins to the left auricle of the heart.

The portal circulation can be looked upon as a loop line out of the systemic circulation. The blood passes to the stomach and intestines. Here it has a special function to perform—namely, to collect and carry food-stuffs in solution to the body. It collects through its capillaries into veins which do not pass directly onwards to the heart, but enter another organ, the liver, where again these vessels break up into capillaries, and form on emergence from this organ another set of veins which join up with the main systemic vein, and thus pour their contents into the right auricle.

It will be seen then that the systemic system provides an immense amount of work for the left ventricle, and consequently the muscle wall of this pump is exceedingly thick—three times the thickness of the muscle wall of the right ventricle—which only has to pump its contents through the lungs and thence back to the heart.

We now have a general idea of the circulation, the functions of the blood, and what happens to it during each contraction of the heart—namely, it passes through every organ of the body, bringing nourishment and oxygen to each, and returning with waste products from the same.

Its passage through any organ of the body may be illustrated by means of a sponge. Imagine that a sponge be placed in our tube circuit. On one side is a tube bringing blood to the sponge; it ramifies through the meshes of the sponge which now represent the capillaries, and leaves by a single tube on the opposite side. Whilst in the meshes of the sponge the interchange of gases and food-stuffs for waste products takes place.

The blood then on entering the heart through the right auricle is rich in food-stuffs and waste products having returned from the whole of the body, including the digestive tract, but is deficient in oxygen, which it has given up to the various organs. It passes thence into the right ventricle onwards through the pulmonary artery to the lungs, where it again gets its supply of oxygen and returns to the left auricle; thus purified and with its food-stuffs still left it is thence propelled from the auricle to the ventricle, and from the ventricle to the general circulation, again bringing oxygenated blood and food to the tissues. This is the whole scheme of the circulation of the blood which goes on rhythmically and regularly as long as life lasts.

CHAPTER III

THE RESPIRATORY SYSTEM

WE now come to our next system, the respiratory system. Let us first take the component parts of that system.

These are the nose, throat, larynx, trachea, bronchus (two, left and right), and lungs.

It is necessary to keep these component parts in our mind, because each has a special function for the perfect carrying out of the respiratory process, which is the oxygenating of the body. Let us look then at these parts separately.

The nose has two apertures leading from the outside air to the pharynx. Its function is first to warm the air drawn in, to add moisture, and to filter impurities from it.

The pharynx or throat is a roomy space at the back of the nose. It is dome-shaped, and in front, as we have seen, has two wide openings from the nose. Opposite these, at the back of the space, are two small openings which convey air by means of the Eustachian tube to the auditory apparatus, one on either side.

The mucous membrane lining the pharynx is richly supplied with gland tissue. These glands are aggregated into three masses known as tonsils, two of which are seen, on looking into the open mouth, situated one on either side at the back of the throat, and one which is not seen situated immediately at the back of the nose. The function of these masses of gland tissue is to act as filters of impurities. They are on guard to prevent any impurities which have penetrated the first barrier, the nose, from passing on into the delicate structure of the lungs.

The pharynx leads to two passages: the larynx in front, the œsophagus behind.

The larynx is to conduct air into the lung, the œsophagus to conduct food down into the stomach. The larynx is situated immediately at the root of the tongue, and is guarded by a special valve, the epiglottis, which closes or folds over it during the act of swallowing, so that food does not pass into the larynx, but passes over the top of the larynx into the œsophagus.

The larynx is the beginning of the air tube known as the trachea. This is a tube permanently open by reason of rings of cartilage in its walls, and passes down into the top of the chest. Here it divides into two tubes of similar structure known as bronchi, the right and the left. These subdivide, that on the right side into three, the other on the left into two similar but smaller tubes, which pass on thence to the several lobes of the lungs. The lungs consist of three lobes on the right and two lobes on the left. As the branches of a tree spring from one central trunk, so the divisions and subdivisions of the bronchus present the appearance of branches springing from a central stem. Each tube is, of course, hollow, and its final ending is a small blind and bulbous swelling, extremely thin-walled, which constitutes an air cell.

These minute cells all closely packed together constitute the tissue of the lung. The interior of them, as we see, is continuous with the outside air, and outside each cell the capillaries of the pulmonary artery ramify.

The capillaries have virtually no walls, and the bulbous end or air cells of the bronchi have also exceedingly thin walls; consequently the blood is brought into close apposition with the outside air in this position, and it is here that the interchange of oxygen from the air and carbon dioxide from the blood takes place.

We have already seen that the red cells of the blood have a special affinity for oxygen; they take hold of the oxygen, which is chemically free and uncombined in the air, and carry it into the body, and the carbon dioxide, which is a chemical compound formed in the body by using up the oxygen, is passed out into the expired air as a waste product. Both are gases, hence we talk of the interchange of gases in the lungs.

The function of the lungs then is a double function :—

(*a*) To provide oxygen for the body.

(*b*) To excrete waste products, of which one is carbon dioxide.

The mechanism of breathing is by means of certain muscles known as the ordinary and extraordinary muscles of respiration. The ordinary muscles are the diaphragm and the muscles of the abdomen, together with the small muscles placed between the ribs, known as intercostals; the extraordinary are the powerful muscles of the trunk, at the back, side, and in the neck.

The act of breathing is performed by a descent of the diaphragm, coupled with the bulging of the abdomen.

The diaphragm is a flat muscle stretched like a tent across the middle of the body, with the apex of the tent pointing upwards. When this muscle contracts the dome of the tent disappears; a vacuum is thus produced in the chest, and to take its place air rushes in through the respiratory tract. This is the act of inspiration. The capacity of the chest is increased, and, as a result, fresh air containing oxygen is brought into immediate relation with the blood.

At the end of inspiration the diaphragm ceases to contract, the dome of the tent returns once more and thus reduces the chest capacity, and the inspired air rushes out. This is the act of expiration, and it is made more forcible by the falling in of the chest wall, aided by the contraction of the abdominal muscles.

This process is repeated in normal circumstances, in the adult about fourteen times per minute; in a new-born infant the breathing is much more rapid, thirty to forty breaths per minute being quite normal.

The lungs are covered by a smooth shining membrane, which also lines the chest wall. Its function is to allow of free movement of the lungs inside the chest. It is called the pleura, and we shall discuss it with the peritoneum, a membrane of similar structure.

The mechanism of the respiratory apparatus and the position of its component parts must be remembered, in order that we may appreciate their relative importance when we come to the study of diseases.

The nose should always be kept clean in an infant, for it is surprising how dirty it becomes in a great city like London. Each morning and evening, as part of the toilet, the nostrils should be carefully wiped out by means of a pledget of cotton wool rolled up into the shape of a pencil, and soaked in warm boracic lotion or even simply plain warm water, following this up with an application of vaseline or boracic ointment.

CHAPTER IV

THE EXCRETORY SYSTEM

The Kidneys

WE saw in our last chapter that the lungs had two functions, one to supply oxygen to the blood, and the other to excrete carbon dioxide.

We have now to discuss another excretory organ, the kidney.

The kidneys, two in number, are situated at the back of the abdomen, close to the vertebral column, one on either side. Being extremely delicate and sensitive, Nature has taken especial care of these organs, and has surrounded them with a large amount of fat, the object being to maintain the heat of the kidneys at a uniform temperature, and also to prevent shock from injury, direct or indirect.

Each kidney has attached to its upper end a special ductless gland known as the suprarenal, which has a special function, and must not be confounded with the kidneys. The structure of the kidneys is best understood if we again contemplate a sponge. If we imagine the network of our sponge to consist entirely of small tubes closely packed together, then we can understand the structure of the kidney, for its substance is composed almost entirely of tubules closely packed together; each tubule starts from a small blind end—the glomerulus or small globe—situated at the outer border, and runs to the centre of the kidney. Here is a wide funnel-shaped collecting chamber into which the mouths of the tubules open. From this collecting chamber, known as the hilum of the kidney, runs the ureter, a single tube the size of a goose-quill which opens into the bladder. The little globes are surrounded by blood capillaries brought by blood-vessels from the systemic circulation, and it is here exactly, as in the lungs, that the blood gives up some of its waste products, of which urea formed from the decomposition of the nitrogenous elements is the most important. These waste products of the body are held in solution by the watery part of blood, and pass from the blood-vessels into the little globes, and thence on in a fluid known as urine. This urine passes along the tubules into the hilum of the kidneys, thence from each kidney it is carried by the ureter to the bladder. Here it is collected until the bladder is filled, when automatically it empties itself by means of the urethra.

Hence we see the function of the kidneys is to filter out waste products from the blood, and to cast these out of the body by means of a somewhat complicated system of tubes.

In addition to this excretory function of the kidney, there is a second function known as the glandular function. We shall learn the glands of the body later on. I will only say here there are three types of glands:—

(*a*) Those with ducts, as the parotid and lingual.

opening into the mouth; the liver and pancreas opening into the intestine.

(*b*) The ductless glands, as the thyroid, which has no duct, but pours its secretion directly into the blood, and

(*c*) The lymphatic glands, which act as filters of the body fluid, have no special gland secretion, and are found throughout the whole of the lymphatic system in the body.

Now the kidney belongs to class (*b*); in other words, it has a glandular function. It possesses the power of forming a substance which we may call kidney extract, which is necessary for the bodily health. Even though the kidneys stop secreting altogether, yet the patient does not immediately die; life can be supported for from ten to twelve days by means of this kidney glandular secretion. We see then two different functions belong to the kidneys:—

(*a*) That of excretion, which is mechanical, and

(*b*) A glandular function supplying kidney extract to the body.

And further we learn that the second is complementary to the first. If the mechanical part fails, the glandular part can for a time carry on.

The function of the suprarenal glands is imperfectly known. They form a glandular extract which is necessary for the bodily health, and we know that that extract has a very marked influence on the involuntary muscles of the body—that is to say, not upon the big muscles of the skeleton, but upon the muscles of the heart, blood-vessels, and intestines over which we have no voluntary control.

The suprarenal extract also has some influence upon the nourishment of the body, because when there is disease of the suprarenal there are definite signs in the skin and elsewhere of disturbance of nutrition. Like the kidney, the suprarenals belong to the class of ductless glands.

CHAPTER V

THE ALIMENTARY SYSTEM

The Digestive Tract

WE now come to the study of the system of digestion.

The digestive apparatus in us warm-blooded animals is very highly developed, in order that we may derive nourishment from a large number of different food-stuffs. In the amœba, it will be remembered, there is no evidence of any differentiated digestive apparatus, the needs of the organism being supplied by the digestive power of the protoplasm. As, however, we trace the development of higher and higher organisms, so we find some form of apparatus for the digestion of food makes its appearance; the higher the development the more varied is the diet, and the more complex is the digestive apparatus.

In man, in its simplest form, the digestive apparatus may be looked upon as a single tube passing right through the centre of the body with an opening at one end, the mouth, for the entry of food, and an opening at the other end, the anus, for the dejection of waste products.

The walls of this tube are muscular—are composed, that is, of muscular fibres, with a circular arrangement around the tube. It is lined by a delicate membrane known as the mucous membrane, and between this and the muscular layer a very large number of glands is found. These have ducts opening into the interior of the tube, and secrete juices for the digestion of food-stuffs passed into the tube from the mouth.

There are thus two functions to remember belonging to the digestive apparatus, one the purely mechanical for the entry into the body of the food-stuffs, and the passage of them on to its exit, and the other the function of breaking up the food-stuffs into soluble constituents, in order that they can be conveyed to the organs of the body by means of the blood and lymphatics to maintain the life of the individual.

As the development of a digestive apparatus becomes more intricate the higher we go in the animal world, so we have to remember that there is a gradual development from the early days of ourselves in infant life to the perfect digestive apparatus which we find in adult life; in other words, the infant digestive apparatus, though structurally as complete apparently as that of the adult, is unable to cope with the mixed diet that is used by adults. We must remember this to understand the difficulties attending the dieting of our infant.

Taking first the mechanical function of the digestive apparatus, we will start with an account of the constituents forming that apparatus.

These are :—

The mouth, which contains after the first year the teeth.
The tongue.

The pharynx.
The œsophagus.
The stomach.
Small intestine : (*a*) duodenum, (*b*) jejunum, (*c*) ileum.
Colon (large intestine) : (*a*) ascending, (*b*) transverse, (*c*) descending.

These constituents of the digestive apparatus are in reality one long tube, a muscular tube, differentiated in parts for special purposes, as we shall see later; but the mechanical part of the digestion is carried on by voluntary muscles in the mouth and pharynx, and by involuntary muscles from œsophagus to anus, which surround the whole tube, and by their action pass the food-stuffs on in one direction from the œsophagus to the anus.

Let us then trace the course of food through this long tube.

Taken into the mouth a bolus of food passes down the œsophagus, which is situate behind the windpipe, to the stomach.

This may be conveniently likened to a flask with a narrow inlet and outlet. The upper end is known as the cardiac end of the stomach, and is situated behind the lower end of the breast-bone. Into this end the œsophagus opens. The lower end or outlet of the stomach is known as the pylorus, and this opens into the small intestine. The pyloric orifice is reinforced by a band of muscular fibres, which by contracting form a sphincter or stopcock by which the contents of the stomach are retained for the process of digestion. As soon as the sphincter relaxes, which it does when the food has attained a certain degree of acidity, the contents of the stomach pass on into the small intestine. The stomach, as I have said, may be likened in its shape to a sort of pear-shaped flask or bottle, and its capacity is not much more than 3 oz. in infants six months old. In quite young infants the capacity is less, not more than 1½ oz. The pyloric sphincter soon relaxes during a meal, hence an infant is able to take feeds of 4 or 6 oz. in amount with perfect ease, whereas this would be impossible if the sphincter remained tightly closed until the meal was ended.

From the stomach, through the pylorus, the food passes on into the small intestine. This is a narrow tube in the infant, about 4 to 6 ft. long, thrown into many folds in order to pack it comfortably into the small space of the abdomen, and divided into different portions, for the purpose of description, into duodenum, jejunum, and ileum. There is not very much difference to the naked eye in these three portions of the small intestine. The difference is, first of all, in the character of the inside lining, and secondly, in the character of the glands and their secretion. The differences of the lining are visible to the naked eye on opening the bowel, but those of the glands are not.

The food remains in the small intestine some considerable time, and passes on thence to the large intestine or colon through a small opening—the ileocæcal valve. This name is coined from the two neighbouring portions of bowel, the ileum and the cæcum, which is a saccular dilatation of the first part of the big bowel—the ascending colon.

The valve action is due, as in the case of the pylorus, to a strengthening band of muscular fibres round the opening. This band by alternately contracting and relaxing allows jets of fluid to pass rhythmically from the ileum into the colon, and prevents a continuous flow of liquid onwards. In other words, it holds up food-stuffs in the small intestine to allow of complete digestion, exactly as we saw is the case with the pylorus.

Into the cæcum also opens a blind piece of rudimentary bowel—the vermiform appendix. It is about 1½ to 2 in. long in the infant, and does not contain any fæcal matter. This appendix is not necessary for digestion in our economy, and is therefore rudimentary; but in some animals, as, for example, the rabbit, it is very large, and an important sort of second stomach for the thorough digestion of the food.

From the cæcum the food, now thoroughly digested, passes on up the ascending colon, along the transverse colon, and down the descending colon to the anus, where it is ejected three or four times daily. The lowest portion of this part of the gut is known as the rectum.

On its way through the digestive tract the food meets the secretions not only of the glands in the walls of the stomach and intestines, but also of two important glands, the liver and pancreas, which are situated outside these walls.

The liver is a large glandular organ divided into two lobes, right and left, situated on the right side of the body just below the diaphragm, and just covered in by the lower ribs. Its weight is—in an infant—about 8 oz. It secretes a peculiar or special fluid known as bile, which passes out from its substance through smaller collecting ducts to form one big duct, which immediately outside the liver expands into a bladder known as the gall-bladder, for the purpose of storing up bile against requirements.

This duct passes on at the back of the abdomen and meets with another duct, that of the pancreas, to open by one common opening into the duodenum—that is to say, the first part of the intestinal tract. It will be remembered that the stomach ended off at the pyloric orifice which opens into the duodenum; immediately below this is the orifice of the common bile duct.

The liver is a large gland made up of special cells. Its blood supply is peculiar. For, in common with every organ in the body, it is supplied with blood from the systemic circulation, and as well it receives blood from the stomach and intestines, which is brought to it by the portal vessels, and is rich in soluble food-stuffs from these sources.

The function of the liver then is twofold. It acts as a filterer of the food-stuffs coming in the portal vessels from the stomach and intestines, and it acts as a storehouse by retaining in its cells a large part of the food-stuffs thus brought to them.

Its peculiar secretion—the bile—is necessary to aid digestion, and especially the digestion of fats.

The other gland—the pancreas—lies far back against the vertebral column, and is much smaller than the liver, being in the infant only about $\frac{3}{4}$ oz. in weight; it secretes a special gland substance which is necessary for the digestion of the starchy or carbohydrate elements in our food.

As we have seen, there are other glands throughout the whole of the digestive tract. In the mouth there are glands; in the tongue there are glands; outside the mouth, but connected with the mouth cavity by ducts, there are other glands, as the parotid, on either side of the jaw in front of the ears, and the sublingual glands below the lower jaw. The duct from the parotid opens into the mouth through the upper jaw; that from the sublingual glands into the floor of the mouth beneath the tongue. These glands are the salivary glands which secrete the saliva with which we are all familiar, and which has a special though faint action in digesting starch.

Probably everyone has experienced the ready flow of saliva when hungry at the smell or sight of food. It is due to the action of these glands. In this instance it is a reflex act, but the same thing happens when food is taken into the mouth—by actual contact with the mucous membrane.

In the walls of the œsophagus a few glands are found, opening by their ducts directly into the lumen of the tract; but it is in the stomach and intestines where we find our highly differentiated glands, and these we will proceed to investigate.

In the walls of the stomach the glands are exceedingly numerous and of several varieties, which secrete peculiar substances for the purpose of digestion. These glands are placed so near the lining membrane that the ducts are extremely short, the glands virtually opening directly into the lumen of the stomach, so that there may be no obstruction by means of a blocked duct. Like the reflex act of salivation in the mouth due to the presence of food, so in the stomach the glands secrete only when there is a stimulus present; when no food is in the stomach the glands are in a resting state and do not secrete.

Similarly to the stomach, the small intestine has walls packed with glands pouring their contents out into the lumen of the tube, and, like the glands of mouth and stomach, they only act under the influence of food-stuffs.

The cæcum and first part of the large bowel contain in their walls many glands, but gradually, as we pass to the termination of the tract, the number of glands in the walls becomes less and less.

We see then the mechanical side of digestion is performed by means of this tubular system, the walls of which are muscular and packed with specialized glands. It also receives by means of ducts, as in the mouth and in the duodenum, special juices. But this tube is not a definite fixed tube, but is mobile and very loosely fixed. The mouth is one fixed point of the tube, the œsophagus is loosely fixed to the trunk, being attached to the vertebral column, but the rest of the tube from the stomach to the anus is freely movable. As I have said, the small intestine is closely packed into coils in the abdominal cavity; these coils must be mobile, must be able to move freely over each other in order to allow of free peristalsis; to give it this mobility, the intestines and also the stomach possess an outer covering known as the peritoneum.

It is a smooth, glistening membrane, which lies in the abdominal cavity and covers the surface of the intestines; to thoroughly understand it we must for for a moment look at the development of the embryo. At one stage in its development we find the embryo as a sausage-shaped mass, hollow in the middle. This hollow space eventually forms the body cavity, and is lined by a smooth, glistening membrane, from which the peritoneum ultimately is derived.

If we now divide the body cavity into two by pushing a thin plate horizontally through the walls we thus get two body cavities, an upper and a lower, each lined by the shining membrane. For our plate has pushed in in front of it the membrane lining the cavity.

In our embryo it is the diaphragm which divides the original body cavity into two. The upper part becomes the chest, the lower the abdomen. Each is lined by a continuous layer of this shining membrane. In the chest it is known as the pleura; in the abdomen as peritoneum. The viscera or organs filling the chest and abdomen are developed from the body wall, and grow forwards into the respective cavities, pushing in front of them the pleura or peritoneum, so that we find the walls of the cavities and the surface of the organs therein covered by a continuous and smooth membrane, and which allows of free mobility.

The lungs are packed close to the chest wall, but separated from it by this double layer of pleura. The space between is known as the pleural cavity.

Similarly, in the abdomen there is a space between the walls of the abdomen and the viscera known as the abdominal cavity lined completely by this same membrane, which is now known as the peritoneum. But the intestines, having pushed further in than the lungs, have become separated from the body wall, and therefore, when free, they are enveloped in the peritoneum and are, in fact, held to the body wall by the peritoneum, which, of course, here is double.

In this position it is known as the mesentery, and in between its layers run the vessels, lymphatics, and nerves.

Thus the intestines are loosely suspended by the mesentery to the body wall, and at definite points—as the cæcum, close to the liver on the right, and spleen on the left—these attachments are short and firm, and are known as ligaments of the intestines.

By means of these ligaments the intestines are retained in their place so that there shall be no kinking of the bowel, which would prevent the passage of contents along their interior.

The need for some form of suspension is at once made obvious if we take an ordinary garden hose-pipe made of rubber. If this is bent too abruptly it becomes kinked, and the flow of water is stopped; whereas, if it is attached by some method of suspension, the flow of water is not interfered with. In exactly the same way the mesentery is placed to act as suspensory ligaments to the intestine. We see then the importance of the peritoneum; its glistening smooth surface, everywhere covering the wall of the intestines, acts as a lubricating surface for the free movement of the intestines upon each other; it acts as a ligament, and is a carrier of blood-vessels and lymphatics.

This completes our study of the mechanics of the digestive tract; we now turn to the study of the digestion itself.

This is formed by the various juices poured out into the lumen of the intestinal tract; those juices we will now consider. I will just pause to remind the reader of the undeveloped state of the digestive apparatus in the infant. Muscularly, and to all outward appearance, it is identical with that of the adult, but its juices are very weak throughout the whole extent of the tract. Nature has provided for this weakness by supplying through the mother a food—namely, breast-milk, which requires little or no digestion.

It is only during the first year that the infant type of digestion persists; after this it follows more or less the adult type. We shall, therefore, study the two types side by side, noting the differences in passing.

Taking, then, the different portions of the digestive tract, the following juices are met with :—

In the mouth, the saliva; this contains a ferment known as ptyalin, which has a weak action upon the starchy constituents of our food. It, so to speak, begins the process of starch digestion, but it is not powerful enough to completely digest starch. It is not found in the infant's saliva until about the ninth month of life.

In the œsophagus there are no special juices, only glands which supply lubricating material into the tube.

The stomach in the adult contains free hydrochloric acid, and on the arrival of food secretes a ferment—rennin—which with the acid digests all nitrogenous food-stuffs. In the infant, on the other hand, there is no free hydrochloric acid. Rennin, however, is present apparently free, and the digestion may be divided into three phases :—

(1) Milk, alkaline in reaction, enters the stomach and is curdled by the rennin.

(2) Rennin breaks up the nitrogenous curd thus formed into peptones with the formation of lactic acid.

(3) With the acid thus formed it converts the peptones into more soluble forms. This acid fluid is then passed on into the intestines through the pylorus.

In the intestine in the adult a strongly alkaline ferment is found which is manufactured in and poured out by the pancreas. Being strongly alkaline it neutralizes the acid contents arriving from the stomach, so that the contents of the intestine are alkaline.

To this ferment the name trypsin is given, and its action is, with the bile from the liver, to finely emulsify fat and to convert the starchy foods, already partially digested by the saliva, into soluble sugars. In the infant, however, this alkaline ferment is not found before nine months. Consequently, there is no change in the intestine of the partially digested food-stuffs arriving from the stomach from acid into alkaline, as in the adult; neither is it possible for the infant to digest starchy food before this period. The contents of the intestines, small and large, in the infant therefore are acid, although the acidity gradually diminishes in the big bowel.

It is not, however, correct to lay down an arbitrary law as to the inability of an infant under nine months to digest starchy foods; on the contrary, it is not unusual to see artificially-fed infants thrive more rapidly by the addition of some starchy food, such as barley water, to their milk feeds; and the need for this appears to be evidenced particularly in those infants who show difficulty in digesting much fat. It seems then that, although most infants do not require any starchy ingredient in their feeds before the ninth month, whose health indeed is impaired by this form of food, yet a few do need it, and these can be educated to digest starch at an earlier age, probably with success from the sixth month onwards.

In addition to the special ferments supplied by the two glands outside the tract, the pancreas and the liver, the small intestine is richly studded with glands in its walls, which pour out their contents into the lumen of the bowel. In addition to the digestive juices poured out by these glands, there is yet one other secretion which enters into the digestive process. I refer to the secretion of the cells of the mucous membrane of the bowel. It has been shown by experiments, notably by a Russian physiologist, Pawlow, that special foods call forth special ferments. It will be remembered what I said about the secretion of saliva at the sight, smell, or even the thought of food when hungry. This is an instance of food calling forth a special ferment.

As we pass down the digestive tract we know that special foods call forth special ferments. Meat, for instance, does not call forth a flow of saliva in anything like the proportion that it causes the secretion of acid and rennin in the stomach. In the same way the acid solution of peptones, thus formed in the stomach, on arrival in the intestine calls forth a secretion of alkaline trypsin from the pancreas.

But this is not all. We now know through the work of Professor Starling that it is not the acid contents of the stomach which excite a flow of trypsin, but the secretion of the cells of the mucous membrane of the bowel. To this secretion the name secretin has been given. It is poured out by reason of the stimulation of the cells by the food exactly as saliva is secreted in the mouth, and by its presence excites the pancreas in turn to activity with the production of trypsin.

It is important to remember this, for we shall then avoid injudiciously overloading the infant with food, or providing unsuitable food, for by so doing the powers of the cells of the intestinal walls will be overtaxed and secretin will not be produced.

This is a real danger, as one sees in post-mortem examination of infants who have died of intestinal disorders. Normally the intestinal walls in a healthy infant are of the thickness of thick blotting-paper, or even somewhat thicker. In those infants, however, dead from digestive disturbances, the walls of the intestines are as thin as the thinnest tissue-paper, one can, in fact, see through the walls as clearly as through tissue-paper, and it can be readily conjectured that, owing to this tax upon their powers, the cells lining the intestinal walls have wasted and lost their function; they have been overworked, and have not had a sufficient resting period in which to recuperate from their exhaustion.

CHAPTER VI

The Lymphatic System

The lymphatic system has been mentioned in connection with the circulatory system. It is indeed necessary to study the two systems together in order to complete our knowledge of the movements of the fluids of the body. Blood we have seen is ever circulating through every organ of the body. It is a vehicle for carrying nourishment to each organ, this nourishment being in solution in the blood serum or watery part of the blood. The blood is retained, as we have seen, in the blood-vessels, and only from the extremely fine divisions of these can the contents emerge. It is through the thin walls of the capillaries that the blood serum oozes, flooding each organ with a constant supply of nourishing fluid.

This fluid has to be collected and returned to the blood; in other words, each organ has to be drained exactly as marshy land has to be drained by a system of drain-pipes. For this purpose then in each organ of the body little channels are formed which join together to make one or more main channels by which the fluid leaves that organ. This fluid is known as lymph, and these channels as lymphatic vessels. They are found everywhere in the body, and follow the course of the blood-vessels supplying each organ. Thus we find the legs drained by lymphatics passing upwards by the side of the main blood-vessels into the abdomen. Here the lymphatic vessels from each leg meet, and form a much larger channel into which drain the contents of the lymphatics from the stomach and intestines. To this large channel the name "receptaculum chyli" is given—the receptacle for chyle—chyle being the term applied to the lymph which comes from the intestines, and which, of course, is richly stored with food-stuffs. Passing upwards in front of the vertebral column by the side of the main blood-vessels it arrives at the top of the chest. Here it receives the lymph flowing in from the arms and head and neck. It is by this time a vessel of some considerable size; in this position it is known as the thoracic duct, and passes on to its termination, opening into the right auricle of the heart.

In this way a constant supply of fluid is maintained in every organ which passes out from the blood-stream through the walls of the capillaries, and returns to that stream by means of the lymphatics. Everywhere throughout the lymphatic system the passage of the lymph is impeded by small masses of lymphoid tissue known as glands, which are placed at intervals along the course of each lymphatic vessel. The fluid before its passage on must first pass through these glands, which therefore act as filterers of the lymph. It is this filtering action of the glands which is so important for the welfare of the individual. Were it not for these barriers along the course of the lymphatic vessels, all impurities in the lymph would pass out of each organ straight into the blood-stream. As it is the glands are so placed to prevent this. In addition, they are composed of lymphoid material—that is to say, of cells which have the special property of eating up or destroying living cells. Cells possessed of this power are known as phagocytes. They exist free in the blood-stream, and especially in these masses of lymphoid material.

These being placed at intervals along the main lymphatic vessel are necessarily found along with these vessels in the neighbourhood of the blood-vessels. Normally, their presence is not perceived; but when inflamed they become swollen, this swelling being obvious to the eye in situations where the vessels are close to the body surface. Such situations are the neck and the groins. Hence it will be at once obvious how swellings of glands in the neck are explained. Some impurity of the mouth, for example, enters the lymph-stream. This passes to the chain of lymphatic glands lying by the side of the great vessels in the neck. By reason of the impurity the glands become inflamed and so swollen. Hence their presence is made manifest by reason of this swelling beneath the skin.

In connection with this phagocytic action of certain cells of the body, it must be mentioned that there are certain aggregations of such cells—collections, that is, of lymphoid material in various fixed positions in the body. Such are the tonsils—similar patches in the small intestine, and one large organ, the spleen.

This organ is situated in the abdominal cavity, high up on the left-hand side, sheltered by the lower margin of the chest wall. It weighs in an infant about ½ oz. It must not be confounded with the lymphatic glands—that is to say, it has not the same filtering action upon lymph as have these glands. It must rather be looked upon as a specialized organ composed of specialized cells, whose function is partly phagocytic in character, but as well possess the peculiar power of rejuvenating the cells of the blood.

It is therefore correct to mention it in our study of the circulatory and lymphatic systems as being part of the lymphoid material of the body, a knowledge of which is necessary to our complete understanding of these two systems.

CHAPTER VII

THE CENTRAL NERVOUS SYSTEM

To understand the central nervous system which is the most highly differentiated of all the organs of the body, let us for one moment consider again the single cell. It is obvious that a cell need not necessarily be round; it can be elongated indefinitely, its protoplasm being drawn out into one long filament with, of course, its nucleus somewhere in its interior.

Of such nature are the cells of the central nervous system, which consists of brain, medulla oblongata, spinal cord, and nerves. As an orange is continuous with its stalk, so the brain, a rounded body, is connected with its stalk, the spinal cord, by means of a short expansion of this latter known as the medulla oblongata. From the spinal cord emerge the nerves on either side throughout its whole length.

The brain is a large organ, weighing in an infant between 1 and 2 lb. It consists of myriads of cells of this filamentous type, each with its nucleus in the brain, and its tail running downwards through the medulla oblongata and spinal cord to its final termination as a nerve in the organs and tissues of the body.

The function of these nerves is to act as telegraph wires, transmitting messages between the brain and the rest of the body.

The central nervous system, therefore, is seen to consist of bundles of nerve fibres, these being filamentous projections of cells, the nuclei of which are aggregated together to form one large swelling, the brain.

From this brain, as from a central telegraph office, impulses are sent down the nerves as messages to the various organs and muscles of the body. Similarly messages are sent back to the brain from these organs. Consequently, we divide the nerves into two kinds, motor and sensory: the motor running, as their name implies, to the muscles, and the sensory to the organs, and specially the skin.

We see then roughly the mechanism and the function of the central nervous system. Being a delicate organ, Nature has provided with lavish care for its protection. The brain and the medulla oblongata are situated in a bony chamber—the skull. The spinal cord is situated in a strong hollow tube, the walls of which are composed entirely of bone, but by reason of the need for flexibility, this bony tube is broken up into segments, these segments being known as vertebræ. Each vertebra consists of a solid front, the body, from which two wings are prolonged backwards, forming when they meet a bony hoop, this hoop being still further extended into a spine. Inside the hoop runs the spinal cord, and through the intervals between the different hoops emerge the nerves. Now the floor of the skull is irregular; the brain if it rested on this surface would consequently be subject to jars when the individual walked, or even moved. Nature has smoothed off the irregularities by a tough membrane which lines the interior of the skull, and is continued down the walls of the hollow tube—the vertebral column.

The brain and cord are surrounded by a very delicate membrane which closely embraces them, and beneath which are the blood-vessels supplying the brain and spinal cord. The name given to these membranes is " mater "; the one outside, being tough and thick, is known as the dura mater; the one covering the brain and cord, the pia mater. But even now we have not quite completed the description of Nature's provision for the protection of the brain. For the purpose of movement and of protection she ordains that the brain should move in a water-bath. This is known as the cerebrospinal fluid, and this is contained in an enveloping membrane known as the arachnoid mater. This membrane is moderately thick but clear, so that one can see through it.

We now have an intelligible picture of the brain and its membrane. Outside, forming the lining of the skull and bony column, is the dura mater; next, attached to it in places for support, is the arachnoid mater, containing its watery fluid—the cerebrospinal fluid; inside this is the pia mater, surrounding intimately the brain and spinal cord.

That is our central nervous system. In addition, there is a second nervous system known as the sympathetic. This consists of masses of nerve tissue known as ganglia, which are situated in front of the vertebral column on either side in the neck and chest. Each ganglion has connecting nerve filaments between the nerves of the central nervous system on the one hand, and on the other with the blood-vessels of the body. Their function is that of quickly supplying impulses for regulating the dilatation or constriction of the blood-vessels, without sending impulses first to the brain.

PART III

THE LIVING TISSUES: THEIR COMPOSITION AND WORKING PROCESSES.

CHAPTER I

THE PATHOLOGY OF NUTRITION

HAVING studied the various systems of which the body of the individual is composed, our attention must now be directed to the methods by which these systems are correlated—by which, in fact, life goes on.

It is then the life-history of the cells of which the body is composed which we must now study. To this study the title at the head of the chapter is applied.

The body is made up entirely of cells, all derived from the fusion of two single cells, male and female. Every organ and tissue is a mass of cells, specialized or different in appearance and function, but still cells, having their origin in this original cell fusion.

The life of the individual is, of course, dependent upon the life of all these cells which make up the organs and tissues of the body.

Every cell then is alive and possesses the property of taking up from the fluid, by which it is surrounded, the substances which are necessary for its individual life, and also the property of throwing out from itself the waste products from the internal digestion of these substances.

Each cell consists of an envelope in which is enclosed the cell substance known as protoplasm, and it is this substance which carries on the perpetual circulation of matter, *i.e.*, the intake of food-stuffs and the extrusion of waste products.

In the centre of the protoplasm is the nucleus, a more compact and apparently more highly developed portion of the cell, which we look upon as the presiding genius of that cell, just as the central nervous system is the presiding genius of every organ and tissue of our body.

But the life of each cell is not carried on individually irrespective of its neighbour; the cells are dependent upon each other and upon that great vehicle or carrier, the circulating blood, that we have recently studied. This slowly percolates through every tissue or group of cells, and by means of its watery part, which we know by the name of lymph, maintains in each cell the steady internal circulation of matter, which we call the metabolism of cell life. It is plain then that there is harmonious relationship between the cells, which must be maintained for the well-being of the individual. If one group of cells suffers, then all suffer. This relationship is effected by the circulating blood and lymph. The metabolism of the cell is unceasing; wasting and repairing the waste is continuously going on; through the medium of the circulating blood the lymph or body fluid which surrounds the cells is constantly being recharged with the necessaries of cell life, oxygen and organic substances in solution, and as constantly the results of cell metabolism, carbonic acid, water, and other waste products are being removed by the same medium. This is known as the adaptation of repair to waste. Nothing in life is stationary. There is this necessary change going on in health in every cell in our body. This change is perfectly balanced. In health we eat and drink according to our needs. If we eat too much, Nature, as she is called, steps in. What do we mean in the light of our present subject by Nature stepping in? Clearly cell metabolism goes on. If too much food is taken, the metabolism may for the time being be choked and not work well. But we ourselves do not experience this; we experience no appetite, and so we starve until the balance is again reached. The metabolism of our cells having been re-established, we again experience appetite.

In an infant or growing child, besides the requirements of repair or waste, we must remember that it is necessary to supply food-stuffs for growth—that is, for the formation of new cells.

The adult cells may be looked upon as taking in one constituent (food substances and oxygen), and giving out two products, energy and waste. Infant cells, or those in a growing individual, take in this same single constituent—food-stuffs and oxygen—but give out three products: energy, waste and growth. And this extra product, growth, has to be provided for.

If sufficient nourishment is not given, then wasting or impaired growth will result. But the working powers of all cells are limited; food can be dealt with by the cell metabolism up to a point only—that is to say, food given in excess will for a time call out extra working of the cell protoplasm, resulting in growth at an increased rate, but if the working power of the cell is overtaxed by this extra food, then the metabolic process becomes clogged and stops; metabolism is hampered, and the result is faulty function, either the rate of growth is reduced, or there is actual wasting.

This is very readily seen in the case of infants fed on food too rich in fat and solids. For a time the individual grows rapidly, but then there comes a change—the infant appears ill, it wastes, and is made worse instead of better by an increase of food. What do we know has happened? The cell metabolism at first worked at a greater pressure and built up new cells. There was increased output in the shape of excreta; the infant appeared more lively and full of energy. But then, the power of the cells being overtaxed, metabolism became clogged, or, in other words, the balance of nutrition was upset; growth could not continue by reason of the poor working powers of the overtaxed cells.

There are other points to remember with regard to the history of cell life.

They act as storehouses. The intake of food by the individual is not continuous but intermittent; we take our meals at stated intervals during each day. The cells have, therefore, to become storehouses from which the blood may draw during the periods when food is not taken in by the mouth. Notably, the cells of the liver and of the connective tissue beneath the skin—namely, the fat layer—perform this function. Oxygen, too, is stored up by all the cells of the body.

During sleep the cells store up a large amount of material, hence the enormous importance of rest and sleep to the individual. It is the period for recuperation of the cell powers.

For each resting period produces a fresh store in every cell which represents so much potential energy gained for starting the next day's work.

But, it may be urged, the heart never stops beating. Being composed of muscle—in other words, a collection of muscle cells—it would seem that by reason of its constant action these cells never rest. But that is not so. The pause between the heart-beats known as diastole is the resting period in the heart cells. The longer the diastole the greater the recuperative power of the cells, and, consequently, the better the heart's action. In other words, a slow beating heart is healthy and can perform all its functions; the balance of its cell life is maintained owing to a prolonged resting period. But the rapidly beating heart gets little rest in between the beats; the balance of its cell life is upset, it performs its functions badly. Thus we learn the importance of sleep, for maintaining health and the inter-dependence of cells one upon the other, which we call balance.

Cell activity then depends upon chemical action, each cell throwing out waste products, carbonic acid, water, and nitrogenous waste, the chief of which is urea, and each receiving from the blood its necessary requirements for repair. To make good the loss which the blood sustains by this constant giving up of chemical compounds, it has to be enriched from within and without.

From within the blood is enriched, as we have seen, by the activity of lymphoid tissue, notably the spleen.

From without the individual takes in food, and the necessary constituents of this food are :—

Proteids,
Carbohydrate,
Fats,
Salts,
Water,
Oxygen.

Milk is the form of food that contains all these constituents. The detailed study of milk we shall come to later on. It is, however, necessary to keep in mind the importance of the salts of milk.

The iron salts are necessary for the proper functioning of the blood as the carrier of oxygen, and are stored in the cells of the red blood. These cells are, of course, derived from the mother's blood, and hence at birth the proportion of iron salts to the body weight of an infant is exceptionally high. It diminishes during lactation, as milk contains very little iron, and the infant's powers for repair are low. It is therefore necessary to remember in the nutrition of the infant the possible need for the addition of iron salts to its dietary.

The salts of soda are necessary to all forms of life. The chloride of soda, the familiar table salt, is the most important, for it aids osmosis—that is, the transudation of fluids through the vessel walls, and without osmosis life cannot continue. This salt, too, is lacking in milk, and therefore it is often necessary to add it to the infant's food.

We now leave the pathology of nutrition, which we understand to mean those normal processes by which life is maintained and growth goes on.

It is important to bear this chapter in mind, for without some knowledge of these normal processes carried on in the body we are not in a position to study the feeding of infants, nor yet to understand the changes which occur under abnormal conditions. What these are we shall now see by a study of inflammation.

CHAPTER II

Inflammation

When an irritant is applied to any vascular tissue certain phenomena occur locally at this spot, to which the name inflammation is given.

By vascular tissue is meant a tissue through which blood is flowing, and as blood flows through every tissue of the body, it is clear that the local phenomena observed in inflammation are the same, no matter where the irritant be applied. As cell metabolism is quickened by increased inflow of nourishment up to a point, and this in turn depends upon quickened blood flow, so the greater the vascularity of the tissue irritated, the greater, the more rapid, and more obvious are the phenomena of inflammation.

Take, for example, bone, the brain, the tongue, the skin; in each of these the vascularity is of different degree; that in the bone and brain is low, whereas in the tongue and skin it is high. Consequently, although an irritant applied to any of these tissues will produce the same chain of phenomena occurring in the same order, yet in the last two, the tongue and the skin, they so speedily occur and are so obvious that we will confine our study to local inflammation of these. And as the skin is the more easily observed we will consider the phenomena occurring in this as a result of an irritant, only remembering that what is said of the skin applies equally to any tissue of the body.

It must naturally be assumed that the irritant is not of sufficient power to destroy the tissue, and, further, the period of time during which the irritant acts must be limited. For the tendency of all living cells is to carry on their normal functions without ceasing; any interference with the normal working tends to be corrected, the cell returning to its normal state again as soon as, but not before, the cause of the abnormality is removed.

These points are so obvious as hardly to call for mention. Everyone is familiar with a scratch or cut of the skin—it is followed by inflammation round the seat of injury. The phenomena observed are redness, heat, swelling and pain. These are known as the four cardinal or classical signs of inflammation, and where any large tract of tissue is involved, as, for example, a finger or an arm, loss of function is added as a fifth sign. They are the evidence of Nature's reaction to local injury—her efforts at removal of the cause and repair of the damage done.

What then are the processes in the cells of the part which give rise to these symptoms? They are first of all an increased flow of blood to the seat of injury by dilatation of the blood-vessels. The part becomes red and hotter due to the extra amount of arterial blood brought to the capillaries, and as well is swollen by reason of the greater bulk of blood. This swelling causes stretching of the delicate nerve filaments in the tissues, and hence pain is experienced. Following the passage of the blood onwards, from the capillaries it passes into the veins, which also are here dilated. Owing to this fact, and also to the elastic recoil of the tissues, the onward journey of the blood is slowed down, it then tends to stagnate in the veins. But as well there is a change in the distribution of the blood corpuscles. Normally they flow on, mixed together white and red, in the centre of the blood-stream. In the inflamed area the white tend to leave the centre and arrange themselves along the walls of the veins. Here and there they pass through the vein walls, and when outside they are able to assume their phagocytic action; they become then scavengers in the lymph, which, of course, pervades the tissues. In addition, owing to the extra pressure of blood in the capillaries, even red cells are forced through the walls, and as well some of the fluid part of blood. We thus find in the tissues some free blood, and the term for the passage of this through the vessel walls is extravasation.

As well there is this passage of white corpuscles through the walls of the veins to which the term diapedesis is applied, and an increase of lymph which is known as the fluid exudate. Consequently in every inflammation we find dilatation of the blood-vessels, increased blood flow, and then stagnation, while later there is exudation of fluid in the tissues, some blood extravasation, and diapedesis of the white blood corpuscles.

If the irritant is now removed the inflammation subsides or terminates by resolution. The extravasated blood and fluid exudate is carried away by the lymphatics, the circulation returns to its normal rate of flow, and the normal metabolic processes in the cells of the tissue are again resumed.

For it must be observed that where there is irritation there is first of all disturbance of the metabolic processes of the cells in the neighbourhood of this injury. The cells, indeed, are damaged and function badly, and it is to repair this damage that blood is rushed to the part, giving rise to the chain of phenomena we now associate with inflammation. Hence, too, we see the need for a fluid exudate in the inflamed area. It provides increased nourishment for the damaged cells.

But it is not easy to picture any irritant being both sufficient to start this chain of phenomena and at the same time to be capable of removal without doing further damage. In effect it is the intensity and persistence of the irritant that determine the final end of inflammation. We know that many inflammations subside, and others again terminate in abscess formation. Or, again, there is actual destruction of tissue either by a knife or a severe caustic, as a red-hot iron. We know that in time Nature effects a repair, and that this repair is first of all preceded by inflammation. What then happens? Let us consider a boil on the arm. It is due to a local irritant settled in the tissues beneath the surface of the skin. We have all the evidence of inflammation, the signs of which we now possess, and as well there is present "matter," or pus, which eventually is extruded where the abscess breaks. What is the chain of phenomena here? First, the irritant poison is implanted in the tissues, and at once the tissue cells are damaged. There follow increased blood flow and outpouring of lymph, together with diapedesis of blood corpuscles. Some of the tissue cells and blood corpuscles die as a result of the poison, and this is naturally most intense in the centre of the damaged area. Consequently in this position is produced a milky fluid known as pus, which thus is seen to consist of lymph and dead tissue cells and blood corpuscles. By reason of the fluid nature of the exudate the poison is diluted, but unless very minute in amount the poison continues to act as an irritant until much pus is formed. This pus now acts on the surrounding tissues as an irritant, even though the poison is neutralized by dilution, so that we get a central liquid area increasing in size surrounded by zones of inflammation of varying degrees of intensity, ever advancing until finally the surface of the skin is reached; at one spot this in turn liquefies, and the abscess or boil bursts. In this manner the irritant is removed, and until its removal inflammation in the surrounding tissues persists. Upon its removal the inflammation subsides; some of the fluid exudate is absorbed through the lymphatics, some is discharged through the wound, but the remainder—the greater part—is utilized by the living cells around, which not only regenerate themselves, but also reproduce themselves. In other words, there is new tissue formation by which means Nature bridges over the gap caused by damage.

In the same way an eschar caused by hot iron or caustic—that is to say, where the irritant is sufficiently powerful to destroy tissue—is finally removed by inflammation. The dead tissue itself becomes the irritant, and persists as such until it is finally loosened by the liquefying process in the inflamed area around. The inflammation then subsides, and repair of the damage is brought about by the cell growth in this area.

In this way then by means of inflammation Nature brings about repair after injury. Inflammation is the necessary sequela of injury, and terminates either in resolution, in abscess formation, or in new tissue formation. Further, we learn that these changes depend on the intensity and persistence of the irritant causing the injury, and also to a great extent upon the nature of the tissues. Where these are loose much fluid can be quickly poured out, thus speedily diluting the poison—if such be the irritant—so that it no longer acts as such. Abscess formation does not then so certainly follow as when the tissues are dense or the irritant is incapable of solution.

Take, for instance, pneumonia, which is inflammation of the lungs. The tissues are loose, and directly a portion of lung is invaded by the pneumococcus, the organism which causes pneumonia, enormous quantities of fluid are poured out into the tissues, which eventually neutralize the poison of the organism. Inflammation ends here in resolution; abscess formation is excessively rare.

On the other hand, take a foreign body such as a piece of shrapnel. This is quite incapable of solution by the fluid exudate and white corpuscles; it consequently acts as an irritant persistently and produces large quantities of pus, which eventually finds it way by the steady spread of inflammation to the exterior.

This is the history of the changes occurring locally in any collection of cells of the body whenever an abnormal element is introduced. We can thus understand the classical definition of inflammation, which is :—

" Inflammation is the term given to the succession of changes which occur in a living tissue when it is injured, provided that the injury is not of itself sufficient to cause the immediate death of the tissue, these changes constituting the attempt at repair by the cells composing that tissue."

We realize then that it is Nature's method by which she reacts to injury. But besides the local manifestations of inflammation we find the whole organism is affected in turn by this local disturbance. Remembering that the cells of the body are interdependent, we should expect to find the balance of the whole organism upset by any disturbance of a part, and this is exactly what happens, as exemplified by fever.

Fever is the term used to denote a rise of the body temperature above normal.

The normal temperature of us mammals is 98·4° F. How is this produced, and how regulated? It is produced by the chemical changes ever going on in the cells of the body. It is regulated, as will be remembered, by the co-ordinated action of the blood-vessels and the skin.

In considering the functions of the skin we saw that, by sweating and by dilatation of the blood-vessels, heat was given off from the body by evaporation and by direct cooling of the increased amount of blood brought to the surface of the body through the dilated vessels, and so into contact with the outside air.

Conversely in cold weather the skin contracts in a way with which we are all familiar, " goose flesh " resulting. Owing to this constriction of the surface vessels the supply of blood to the skin is restricted; the warm blood is retained in the central organs, and very little is allowed to come in contact with the outside air. The temperature, therefore, of the blood and, of course, the body, is not unduly lowered. In this way a balanced temperature of the whole body is maintained.

Now by our study of the pathology of nutrition we have learnt that a perfect balance is maintained between all the cells composing the whole organism. If then in inflammation this balance is upset, we might expect to find the manufacture of heat also disorganized and its regulating mechanism working badly. If so, it might be supposed that the temperature might fall below instead of above normal. But in reality the principal cause of body temperature, activity of cells, is increased. There is more chemical change going on in the cells of the body, and consequently there is greater production of heat. In addition, the balance of the regulating apparatus—namely, of the skin—is upset. For the skin is, as we know, hot and dry in a patient suffering from a fever; this faulty action of the skin does not allow of the cooling of its surface by evaporation, and therefore there is still further a tendency for the body temperature to rise. It is not until the skin begins to act properly by sweating that the temperature begins to subside and the patient is more comfortable.

Consequently the tendency in inflammation is for the body temperature to rise and not fall.

A good illustration of this can be obtained by a study of pneumonia. Pneumonia is a local inflammation—inflammation of the lungs, as we have seen—and the changes going on in the inflamed lung are the ordinary changes of inflammation. As a result of this local inflammation the balance of the other cells of the organism is upset, fever is the consequence. The patient is feverish, complains of pain, has a hot, dry skin, and this condition is maintained for a definite time—that is, the time taken by the cells of the body to reconstitute the balance. This time is roughly six days. We see a patient with pneumonia very ill with a high temperature; usually this temperature remains at this same high level all the time, and if it is maintained at a level of about 103° F. we take a favourable view of the prospects of that patient's ultimate recovery. Why? Because we know that the reaction of that patient, or, in other words, the tendency to return to the balance in that person's cells, is very strong, as indicated by a high temperature. Nature has reacted strongly to the poison; there is much inflammation locally, and, provided the strength of the individual can be maintained, this inflammation will neutralize the poison of the infection, will end in resolution, and thus the cells will be restored to their perfect metabolism. If, on the other hand, we have a low temperature in a case of pneumonia, we know that we have reason to be anxious, for a low temperature shows low working capacity of the cells, a poor reaction to the poison. Then return to the balance will be slow, or the activity of the cells will be defeated, and the death of the patient ensue. When the balance is reached, when resolution of the inflammation is about to begin, we recognize it by what is known as a crisis. The first thing is the proper action of the skin, the patient perspires profusely, and, from being extremely ill, in a very little while is, comparatively speaking, "comfortable," and expresses himself as being so.

Fever then is one of the symptoms of inflammation —evidence, that is, of disordered balance. Other symptoms occur as a result of fever upon the various organs—brain, heart, lungs, digestive organs, kidneys. They all function badly; in other words, have their balance upset. A feverish patient is delirious, giving evidence of disordered function and working of the brain. The heart's action is quickened, there is shorter diastole, a shortened resting period between the beats, the heart's muscle consequently gets less and less repair. The lungs similarly do not work so well. On account of the poor working of the heart the blood circulates less efficiently, and is therefore not sufficiently oxygenated at each inspiration; consequently the respirations are quickened to overcome this.

The stomach does not work so well, may even refuse to work at all. Digestion is imperfectly carried out, and there may be vomiting. Vomiting, indeed, is frequently the first sign of a rise of temperature in an infant. It is important in all cases of fever to remember this poor working of the stomach and intestines. They cannot perform their functions properly, the balance of the cells of the body being upset, and therefore in all sick persons it is essential to feed them sparingly on a low diet. Still more does this apply to the kidneys. They function badly; they have extra work to do on account of increased output of waste products as a result of increased cell activity, and it is therefore most important to lighten their work as far as possible by limiting the amount of food-stuffs taken into the system. By again referring to our study of the pathology of nutrition we know that there need be no anxiety about starving our patient by this treatment, because all cells of the body act as storehouses, and in a fever the nourishment thus stored in the cells is ready to hand already digested and sufficient to carry the patient along for a certain time. As soon as this food-stuff is used up the balance of the digestive organs is probably returning, and it will be noted that the patient is ready to take more nourishment.

Owing to the outpouring of the fluid exudate in inflammation and the consequent draining of the tissues of fluid nourishment thirst is always a prominent symptom of all fevers. This can be readily relieved by drinks of water. It is obviously necessary to supply this in abundance to all fever-stricken patients.

This then completes our study of inflammation. We have its definition. We know its method of working by our study of local inflammation; we know that the balance of all the cells is upset, consequently we readily accept fever and its train of symptoms as a necessary part of inflammation, and we know from our study of the pathology of nutrition that it is Nature's means of restoring the balance and of effecting repair.

CHAPTER III

BACTERIOLOGY

THIS subject introduces us to the study of bacteria or germs.

At the mention of germs most people, I imagine, form a picture in their minds of some disease. As the majority of diseases with which we are acquainted are caused by germs, so the conclusion seems to be drawn by most of us that all germs are the cause of disease—that is, bring disease in their train.

Now, in my opinion, this is not the correct way of reading Nature. All mackerel are fish; that is a truism no one can dispute. But it is quite incorrect to say that all fish are mackerel. Similarly, although disease is produced by germs, it is equally incorrect to say that all germs produce disease, that this alone is their function.

Let us then look more closely into the way Nature works; we shall then learn that there are good and bad germs, the former being necessary for our economy. Indeed, that appears to be the law of Nature. She is ever working through these minute organisms which abound everywhere for the gradual removal by digestion of all dead or effete matter.

For all Nature teems with living germs or organisms. The soil is full of organisms, plants are covered by organisms; animals, we ourselves, are surrounded by bacteria or germs. But we are not in consequence the victims of disease at all times.

In our study of Nature's ways we have seen that life is preserved by feeding on suitable food-stuffs held in solution. If these food-stuffs are not in solution, Nature builds up a definite digestive system capable of dealing with them. We have learnt in our study of the infant how this digestive apparatus is gradually evolved. We have seen the mechanical side and the chemical side of this, but that does not complete the whole story. There are organisms necessary to the final splitting up of the food-stuffs even after it has been taken into the mouth and passed on through the digestive tract. These organisms inhabit the bowel, and are good germs, because they are performing a function necessary to our health.

Similarly, outside the body bacteria are ever at work for a good purpose. Take a simple illustration; a mushroom that has been picked and left in the sun for a few days. What is its state, say, at the end of four or five days? It will be found to consist of the same outside shell, but of the fleshy part nothing remains but apparently dust. What has happened? Organisms—germs, that is—have eaten up the fleshy part of the mushroom, and have converted most of it into soluble constituents. They have, in other words, started to remove a dead body off the face of the earth. It only requires a little imagination to see that the whole mushroom would eventually be converted into a heap of soluble powder, and the rain water will dissolve this and wash it away.

We should, then, look upon all bacteria as of this nature, serving some useful purpose in the cosmos. But it is not correct to say they are all good. Probably all have their use in Nature's plan of the universe, but when they get transplanted into surroundings foreign to their normal dwelling-place they may become deadly enemies. Take, for instance, the organism to which I have before referred, living in the bowel and necessary to our digestive apparatus. It is called the colon bacillus. This, in its proper place, is a very good friend; it feeds upon and so completes the digestion of proteids; but it unfortunately tends to depart from its proper place, passing out from the bowel into the blood-stream, where it becomes a dangerous enemy. In the one place it is known for its good work, is non-pathogenic; in the other place it is known for its bad work, the disease it causes, and is then pathogenic.

Other germs with which we are acquainted are directly pathogenic when they invade our bodies, such as the germs of scarlet fever, tubercle, anthrax, and the like. Whether they serve a useful purpose in the arrangement of the universe I cannot say. The point I wish to bring home is that the organisms found in Nature are good or bad, or at one time one, and at another time the other, according to their situation, and with reference to ourselves they are termed non-pathogenic and pathogenic respectively.

These organisms are known as bacteria, and are divided into:—

(*a*) Globular	Cocci
(*b*) Cylindrical	Bacilli
(*c*) Curved or spiral rods ...	Spirilla

The special classification of these need not concern us. Suffice it to say they are unicellular organisms, extremely minute, measuring across not more than $\frac{1}{25000}$ of an inch in one direction, and capable of extremely rapid growth. This is by two methods :—

(*a*) By cell division.
(*b*) By sporulation, *i.e.*, by spores.

The bacteria that have spores are the bacilli and some spirilla. Spores are really part of the organism highly differentiated, not seeds, as might be supposed. Each organism is surrounded by a very delicate envelope, but each spore has a tough resisting coat. All bacteria can be destroyed by a moderate degree of heat, usually requiring a lower temperature of moist heat than when dry heat is applied. The temperature is different for different bacteria. Chemicals also destroy bacteria—namely, carbolic acid or iodine solutions. It is different, however, in the case of spores. These, owing to the density of their capsule, are very resistant, and require very high temperatures or very long exposure to chemicals to kill them.

The cocci are minute globular cells, measuring not more than $\frac{1}{25000}$ of an inch across. They grow by cell division alone; they have no spores. If the division is only in one plane, then chains are formed, and to these the name of streptococci is given; if, however, the division is irregular, then masses of cells result rather like a bunch of grapes to look at. Hence to these is given the name staphylococci. The cell division may only, however, result in two cells, these two apparently being united by a capsule surrounding them. They are then known as diplococci.

The bacilli are rods of varying lengths, but of a thickness of about $\frac{1}{25000}$ of an inch. They may be mobile or non-mobile. If mobile, their mobility is due to flagella, *i.e.*, hair-like processes which can be seen to be lashing backwards and forwards in the fluid medium they occupy. They increase either by division or by spores. The spore is a small spot inside the bacillus, which, as we have seen, is extremely resistant to heat and chemical agents, and which appears to grow by the death of the surrounding mother cell. This outer layer of protoplasm disappears, and the spore eventually grows into an exact replica of the mother cell, again producing another spore in its interior.

The spirilla are cylindrical cells, either forming a corkscrew-like spiral thread, or just a curved or comma-shaped cylinder.

The comma-shaped bacilli may be united to each other end to end with their curves alternating, and so a wavy chain is produced. Their mobility is due either to straightening out the curve or by the flagella already described; their growth is either by division or by sporulation.

The part played in Nature by bacteria is to split up into simpler substances the complex organic masses of dead plants and animals, or of their excreta during life. Their food, therefore, is very varied. They require moisture for their existence, although for a time they can stand drying. Spores, indeed, will stand drying for years, and yet, if after this they are given a suitable medium to grow in, they will resume active life. The nature of the gases in which they grow is important; while some can only grow in oxygen, others cannot live in it; others, again, may prefer oxygen, but can learn to do without. All bacteria require some warmth for growth. The most favourable temperature is about 65° F., *i.e.*, ordinary summer heat; but cold and increased heat do not necessarily kill them. Their vital properties are paralysed by cold for the time being; when the cold is removed growth begins again. Light they do not like. Bright sunlight or electric light if long continued is fatal to many bacteria.

All bacteria appear to produce as waste products substances that are poisonous to themselves. This can be seen in the laboratory. When grown on any suitable food, for a time growth proceeds at a good rate. Then it stops. Why? Not because the foodstuffs are used up, but because of the waste products excreted by the bacteria into the medium.

It is interesting to remember this in the study of diseases caused by bacteria. If the poisons generated by bacteria are not powerful enough to kill the host —the individual attacked—then there is this tendency of the bacteria to excrete poisons to themselves, and so rid the host of their presence.

This is what we call immunity—an acquired immunity. The individual has lived down the invasion of the bacteria, has got rid of them by the means we have seen, and in so doing has manufactured substances which remain in the blood, antidotes to further invasion of similar bacteria.

We have an illustration of this with which we are all familiar—namely, vaccination. Vaccination produces an immunity to small-pox. Originally small-pox was introduced into the system by inoculation, but a safer and shorter means has been found and used for years to produce the same result. The inoculation of small-pox is into another animal, the calf; the calf goes through the attack of small-pox as a result, and when it gets well the lymph is richly charged with these antidotes to small-pox. They themselves are capable of producing an inflammation if introduced into another person—ourselves—and as a result of this inflammation produce antidotes, which are stored up in our blood as in the calf. By this means we are rendered immune to an attack of small-pox, but like everything else in Nature there is a tendency to return to the balance; these antidotes are eventually got rid of, and the individual is no longer immune. A further immunity has to be imparted, consequently vaccination is necessary over and over again.

A more shortlived immunity is probably that of a cold. It is an experience of all that we may expect a cold twice a year. This I take to mean that the immunity acquired by one cold lasts roughly six months. Be that as it may, the point to remember is that organisms create waste products, harmful to themselves, and therefore of the greatest use to us in disease.

To recapitulate then, bacteria must be looked upon as necessary to Nature in order to assist in the removal of dead bodies, whether of the animal or the vegetable kingdom. They assist in the disintegration of these or of their waste products.

Putrefaction which we see going on in dead flesh or decaying leaves is essentially being done by bacteria. The souring of cow's milk is also due in part to the work of bacteria. An organism belonging to the streptococcus group, by name the *Streptococcus acidi lactici,* is found in milk of the cow, even when freshly drawn. This milk becomes mildly acid at first owing to the production of lactic acid by a natural ferment in the milk acting upon the lactose or sugar of milk. After a definite period of about eight hours the acidity rises rapidly. This is due to the rapid growth of the organisms named, and which can only live in an acid medium and excrete acid in abundance. Thus the milk increases in acidity, and then, as we know, curdles in about forty-eight hours.

We have seen that non-pathogenic organisms become pathogenic if they find a suitable medium in which to grow. Take the pus-forming organisms, the staphylococci and streptococci. Normally these are everywhere on the surface of our bodies. Owing to the resisting properties of the skin these cannot get into the blood—a suitable medium—but if we scratch the skin so that blood flows we know that suppuration will follow. Hence the importance of sterilizing surgical instruments, hands, towels, bowls, &c. All must be rendered aseptic—that is, free from organisms—sterile.

How do we sterilize? The skin we sterilize by means of chemicals. Tincture of iodine is the preparation that is most frequently used. But for sterilizing instruments, &c., we have recourse to boiling. All bacteria are killed by a temperature of boiling water. The spores, however, are more resistant and require a higher temperature. This is effected by superheated steam—that is, steam forced into a cylinder under pressure. Another means of sterilizing is by pasteurizing, so called from Professor Pasteur, who introduced this method.

Bacteria cannot stand a temperature even below the boiling point of water if subjected to it for a long time. Relying upon this fact, the substance to be sterilized is placed in a water-jacket, and the water-jacket is kept heated for one hour or more at a temperature of, we will say, 180° F.

The bacteria are killed, but the spores remain. These will grow into bacteria in twenty-four hours, when again the substance is submitted to a long continued temperature of 180° F. Again the bacteria are killed, and any chance spores remaining are again allowed to develop, and a third heating after twenty-four hours disposes of them.

By this method of Pasteur's we get a sterile fluid without raising it to the boiling point.

A word here then is necessary to apply the moral of asepsis. For the avoidance of the spreading of disease great care must be exercised to observe the rules of sterilizing hands and instruments. We should not expect to take our meals without a clean fork and knife and spoon; similarly, we should not attempt to touch the skin of a patient, still less a wound, with a soiled hand. Our hands always are soiled with bacteria, so, remembering this, we should not, for the patient's sake, ever go from one to another without carefully washing our hands. For our own sakes also we should remember the universal distribution of bacteria. I am now thinking of the excreta of infants or of any patient and their removal by the nurse. The excreta naturally contain organisms from the body, good and bad. Take the case of typhoid. There are, in addition to the organisms natural to the excreta, the organisms of typhoid. By careless handling of the napkins or bedpan the attendant's hands may very easily become soiled with typhoid germs. It should be the rule, therefore, to thoroughly wash the hands after handling a soiled napkin, otherwise one might introduce the typhoid organisms into one's own mouth at the next meal. Urine and fæces, and the skin even of a patient, should be looked upon as possibly containing organisms capable of spreading disease, therefore, in tending our patients, we should remember the need of scrupulously following out the rules of asepsis.

The production of disease by bacteria is dependent upon two factors:—

(1) The entry of the bacteria into the body where they multiply—that is, carry on their life-history at the expense of their host, and

(2) The production of poisons or toxins.

This is, as we remember, a normal phase in all cell life. Intake of food: output of waste products, which are the toxins referred to. These toxins act, as we have seen, on the bacteria themselves if sufficient time is given. But as the host, by which we mean the individual attacked by the bacteria, has to absorb these poisons, it is of course the host that suffers first. The poisons may be so severe that death results in a few hours, as in a fatal case of septicæmia.

A wasp sting, for instance, produces infection of the blood, *i.e.*, entry into the blood of the pus-forming organism, the streptococcus. This rapidly grows, is distributed by the blood, and produces a poison which the individual infected is unable to counteract. The individual dies.

Or the infection is local—that is, the bacteria gain entrance at one spot and remain there. They then multiply in this situation and form their poisons, which are carried by the lymph into the general circulation, and so the host is poisoned. Diphtheria is an example of this form of infection.

A third mode of infection is an extension of this. There is at first a local infection. After becoming established in this primary seat of infection, the bacteria as well as their poisons are carried by the lymph and blood-stream to different organs far removed from the prime seat of infection. These bacteria then become established in their new sites and multiply, and in their turn produce poisons. Tuberculosis is an example of this form of infection.

We see then that the action of bacteria in producing disease is first of all their entry into the body, their power to exist in this body, to multiply and become distributed throughout the body, and to produce chemical products known as toxins, which in their turn produce tissue changes and toxic symptoms, *i.e.*, symptoms in the host of poisoning.

These symptoms we have already discussed under inflammation. Nature's reaction to the entrance into the body of poisonous organisms is by the local series of changes associated with inflammation, and the sequel to this in the general system is fever, with its resulting chain of symptoms in every organ of the body.

PART IV

CHAPTER I

THE FEEDING OF THE INFANT

General Considerations.

WE now come to a point in our studies which naturally follows upon what we have done.

We have studied the infant as a whole, and we are now familiar with its component parts and with the normal workings of these. We are then in the position of a mechanic towards his steam engine, but as yet we have not learnt to be stokers. For this purpose we must closely scrutinize the food-stuffs provided by Nature for our human engine. Without knowledge of these and of their relative value we can be but sorry stokers.

It has been said that the requirements of an adult in food-stuffs are of a certain nature, and these have to be supplied in certain proportions because of their calorific value. What is meant by calorific value? To understand this let us again refer to the pathology of nutrition. There we saw that each individual cell takes in food-stuffs and gives out energy, which energy can be divided up into heat and work. Again, we can subdivide work into the peculiar property of the cell, such as a muscle cell performing the muscular function, and also the power of the cell to rehabilitate itself. In addition, we know that growth is an output of some special cells, notably the cells of the infant. The energy then given out by a cell is a wide term embracing several different properties.

Now the literal meaning of calories is heat; but it is not correct to say that the food-stuffs we require are only necessary for the supply or manufacture of heat. They are, of course, necessary to supply this energy to every cell. Heat is, however, a convenient unit or coefficient with which to measure food values, and so the calorific value of food means the relative amount of each different food-stuff necessary to be taken into the body to raise the temperature of that body one degree.

In this way food-stuffs are found to have different calorific values. Thus, naming them in the order in which they supply calories or heat, we have first, fat; secondly, carbohydrates; and thirdly, proteids.

Now these three differ bulk for bulk in the amount of calories they produce. Thus one gramme of fat will produce 9·3 calories, whereas one gramme of carbohydrate food or one gramme of proteid will produce no more than 4·1 calories, so that the calorific value of carbohydrates or proteids is less than half that of fats.

We learn, therefore, that fat is the most important element for the supply of calories in our food-stuffs. We know further that a definite number of calories is necessary for the maintenance of health. An infant of seven months requires enough food to produce 700 calories of heat each day; and these calories are supplied by a mixture of fat, carbohydrates, and proteids.

In addition to these food-stuffs certain salts are necessary, as we have seen, and also a relatively large amount of water.

The salts are found in minute quantities in the food-stuffs that we consume, occurring in solution as the salts of soda, of potash, of calcium and of iron. We are, then, now in a position to tabulate our food requirements, which are :—

1.	Fat	calory-makers
2.	Carbohydrates	
3.	Proteids	
4.	Salts	
5.	Water	

Of these elements, the first three are those which supply the calories of heat, growth, &c., to the infant.

As they differ in the amount and energy they supply, it is well to shortly summarize their various properties. Taking them in order, fat is for heat and for growth, the carbohydrates for heat alone. The proteids supply energy to the cells for the carrying on of cell metabolism, and also for the production of the special function of each cell. They are not given for heat, although they are capable of doing the work of fat and carbohydrates in this respect, but only at very great expense. For instance, it would require more than twenty times as much proteid food as fat for the production of an equal amount of heat in the body : obviously a great waste of material. The proteids are also necessary for growth, and are, therefore, very important elements in the infant's diet.

Of the salts :—

(*a*) The sodium salts, as the chloride of soda, are to assist osmosis—that is, the free passage of fluids through the cell wall.

(*b*) The calcium salts are necessary for the formation of bone in the infant in conjunction with the fat, and should always be present in the blood to keep it in a correct state of fluidity.

(*c*) The iron salts, as the oxide of iron, with which we are familiar in everyday life in the shape of rust, are necessary for the absorption of oxygen into the system.

Water is, of course, necessary to hold the food-stuffs in solution and to carry them in that form to their various destinations, and finally to wash out of the system all the waste products of cell metabolism.

Consider for a moment the amount of fluid an infant can drink. Two pints in the twenty-four hours are usually consumed by an infant of three months old, of which at least 87 per cent. or more than three-quarters is pure water. Now compare this with the normal amount drunk by an adult. In addition to the fluids in the food-stuffs, two and a half to three and a half pints of water are the normal requirements of a woman or a man. Compare the weight of an infant three months old with that of an adult woman or man. It is perfectly evident that weight for weight the infant takes an enormous amount more of fluid in the twenty-four hours. The reason for this is, of course, the very weak powers of the infant's digestion and the need for much nourishment to supply growth.

Having thus roughly sketched the requirements of the infant, we will now examine the food with which Nature supplies it. I mean by this, of course, the mother's milk.

Human milk is a bluish-white fluid, alkaline in reaction, of specific gravity of about 1030.

Strictly speaking, it is an emulsion of fat in fluid, which fluid also holds in solution certain solids.

These solids are :—

(*a*) Sugar (lactose).
(*b*) Proteins, *i.e.*, nitrogenous extractives or albuminoids.
(*c*) Chemical salts of calcium, potash, soda and iron.

The percentage composition of human milk, being the average taken from a number of examinations of milk upon which infants were thriving, is given by Vincent as :—

Fat	...	...	...	4·00 per cent.
Lactose	...	...	...	7·00 ,,
Proteins	...	...	...	1·50 ,,
Mineral salts		...	...	0·25 ,,
Water	...	...	...	87·25 ,,

The amount of fat, as also that of the proteins, varies a great deal; consequently many a mother's milk is unsuitable to her offspring's needs. The fat may be as low as 1·50 per cent. or as high as 7 per cent. The proteins may also be low, but usually err on the side of excess, as much as 3·75 per cent. having been found in the milk of some mothers, rendering it, of course, quite unfit for the infant.

The lactose is very constant in amount, seldom varying more than 1 per cent. 6·50 to 7·50 is the percentage composition of this.

The mineral salts are also constant.

Now the specific gravity of a fluid denotes the amount of solids held in solution in that liquid.

Thus, taking water as a unit and writing this down as 1,000, any solids dissolved in this water will raise the specific gravity of this resulting fluid to 1020 or 1030, and so on.

It is clear then that the specific gravity will give us a rough gauge of the amount of solids in the milk, and therefore of the fitness or otherwise of this milk for the nourishment of our infant. Fat, however, is lighter than water, and therefore much fat will give a low specific gravity reading. Consequently a low specific gravity does not necessarily mean a poor milk. On the contrary, it may be rich in proteins and yet have an excess of fat which, in spite of the abundance of proteins, causes the specific gravity to be low. And, again, a high reading may be due to only a moderate amount of proteins, coupled with a low percentage of fat. If, however, we know the percentage of either fat or proteins, we then can tell, by reading our specific gravity, whether or no we are dealing with a good milk. The fat content can be accurately estimated by the Leffmann Beam apparatus, a description of which is here not necessary. A rough gauge, however, of the amount of fat in milk can be obtained by allowing a tumblerful to stand for twelve hours. The cream rises to the top, and forms a layer of varying thickness according to the amount contained in the milk.

The characteristics of the fat in human milk are the small size of the fat globules enclosed in a thin envelope.

By contrast, the fat globules in cow's milk are of much larger size. In addition, these fat globules vary in size in the milks drawn from different types of cows. For instance, in the short-horned cows they are of medium size and fairly uniform. The Jersey cow gives globules of enormous size, though some may be extremely small, but these large fat globules are impossible of digestion by a young infant, and the milk from the Jersey cow should on this account never be used.

From this we see that Nature provides a form of fat which can be readily assimilated with but little effort at digestion on the part of the infant. For the fat globules, being so small, are absorbed without any further breaking up. They can, in fact, pass through the walls of the intestines straight into the lacteals. It is therefore unusual to find an excess of fat in human milk disagreeing with the infant. I have known it occur, but it is far more common to find excess in proteins to be the cause of indigestion in the breast-fed infant.

There are several important points to remember about the proteins, or, as they are called, the albuminoids—the nitrogenous elements held in solution in milk. The word albumen is familiar to us as applied to the raw white of egg. Albuminoid, therefore, means like white of egg, and it is convenient to liken the proteins occurring in milk to white of egg. Indeed, in many respects their properties are identical, as we shall see later on.

Now the proteins of milk are of two kinds:—

(*a*) Whey proteins.
(*b*) Caseinogen.

In human milk the whey proteins relative to the caseinogen are especially abundant in the early weeks of lactation. They diminish in proportion to the caseinogen at six months, and by nine months are of very little account.

Thus up to three months the proteins, which as we have seen form 1·50 per cent. of human milk, are in proportion of 1 per cent. whey proteins, and only 0·50 per cent. caseinogen. A very different ratio between the two is found in cow's milk. Here the total protein content is about 3·50 per cent. But of this only about 0·50 per cent. is whey proteins, the rest being caseinogen, or as König gives the figures as a result of many analyses :—

Human Milk.		*Cow's Milk.*	
Caseinogen ...	0·59 per cent.	Caseinogen ...	2·88 per cent.
Whey proteins	1·23 „	Whey proteins	0·53 „
Total proteins	1·82 „	Total proteins	3·41 „

These albuminoids have different actions when subjected to the same reagents. Albumen, *i.e.*, white of egg, coagulates as everyone knows at a temperature of boiling water, 212° F.; it is also coagulated by contact with weak acids, such as vinegar.

Now of the two classes of albumens in milk, caseinogen is not coagulated by heat, but is by weak acids, and also by the rennin ferment. This coagulum is known as casein. In human milk it is a less dense and less tough coagulum than casein of cow's milk, and is therefore more easy of digestion. The whey proteins, of which lactalbumin is the type, are easily coagulated by heat, but for this purpose so high a temperature as boiling water is not required. Coagulation begins at a temperature of 161·6° F., and is completed at 175° F. They also differ from caseinogen in that they are unaltered by dilute acids or by the rennin ferments. The whey proteins then are by far the most important class of the albuminoids of milk; they are in solution, are not altered in the stomach—are, in fact, ready for absorption by the intestines without any digestion being necessary. Consider then the effect of modifying cow's milk merely by the addition of water. We only want 0·50 per cent. of caseinogen, and we have as above 2·88 per cent. We should have to dilute it with at least five parts of water to bring down the casein content to our needs, and the result on the other constituents, the fat and the whey proteins, would be disastrous; we should have then a mixture containing only 0·80 per cent. of fat, 0·12 per cent. of whey proteins, and 0·46 per cent. of caseinogen, which, with the exception of the caseinogen, is quite inadequate for our infant's needs.

It is conceivable that we could bring up our fat content by the addition of cream, and the percentage of whey proteins by adding the commercial preparation known as lactalbumen to our mixture. It is, however, a clumsy method, and cannot for accuracy of percentage composition compare with the following, which is the method employed in the out-patient department at The Infants Hospital with a very large measure of success.

The principle involved is to use as diluent milk from which the caseinogen has been extracted. This can readily be done by curdling fresh milk with rennin. This ferment, as we know, coagulates caseinogen, but not the whey proteins. Consequently, after precipitating the caseinogen by means of rennin and removing the resulting curd, the milk thus treated contains all the fat, whey proteins, sugar and salts—unaltered. It is known as fat whey. Using this as a diluent, it can at once be seen how easily we are enabled to enrich our milk mixture with food-stuffs, whilst at the same time we dilute the caseinogen.

Take, for example, a milk mixture containing equal parts of milk and water. This, of course, contains 2 per cent. of fat and 1·40 per cent. of caseinogen, while the whey proteins are extremely low, being not more than 0·30 per cent. By adding an equal quantity of fat whey, however, we reduce the strength of caseinogen, but add to the strength of both the fat and the whey proteins.

Our mixture then would read :—

Fat whey	2 parts
Milk	1 part
Sugar water	1 ,,

so that the percentage composition of this would read :—

Fat $= \frac{3}{4} \times 4{\cdot}00 = 3{\cdot}00$
Whey proteins $= \frac{3}{4} \times 0{\cdot}60 = 0{\cdot}45$ or possibly more.
Caseinogen $= \frac{1}{4} \times 2{\cdot}80 = 0{\cdot}70$

which is an excellent modified feed, well in keeping with the component parts of human milk. It can still further approximate to human milk in its characteristics if, remembering that cow's milk is acid in reaction, we neutralize this by adding some lime water, one or two teaspoonfuls to each feed.

To make fat whey correctly, the following details should be observed:—

Take one pint of fresh cow's milk, and warm this to 100° F. by standing it in an outer jacket of hot water. Add about six drops of extract of rennin (Hansen's), and slowly stir. The milk curdles in about ten minutes, and the curd separates from the fat and sinks to the bottom of the vessel. It should be well squeezed to remove any fat collected in its meshes, and then removed as one solid mass. The milk-like fluid remaining is the fat whey. This should now be heated to 150° F. for five minutes to kill the rennin ferment. This is done by boiling the water in the outer jacket. At the end of this time the fat whey should be removed to a cool place and kept cool—preferably on ice—to be used as a stock from which to prepare the feeds.

To make sugar water, dissolve one tablespoonful of sugar of milk, or three moderate-sized lumps of cane-sugar, in one pint of boiling water. This again should be placed on one side as stock from which to draw for making the feeds.

We have now arrived at a clear conception of milk, and also of the methods to be used in modifying cow's milk for infant feeding.

But before applying our knowledge to this purpose, it is necessary to pause for a while to discuss the bacteria in and the effect of heat upon milk. These two points I shall take together in the next chapter.

CHAPTER II

THE EFFECT OF HEAT UPON COW'S MILK

Now the bacteria present in milk should not be lost sight of. Normal human milk is sterile, but cow's milk, owing to the difficulties connected with its collection and distribution, contains organisms, or, in popular language, germs. It is therefore not sterile.

These germs are good and bad. It is a mistake to suppose that all the germs in cow's milk are bad. It is true that many of the organisms belong to the putrefactive class, and are capable of producing poisons if allowed sufficient time and temperature to develop in the milk. But from a study of all the organisms found in cow's milk, we learn that Nature has provided good organisms which inhibit the growth of the bad.

What are these good organisms and their characteristics? They are bacilli and cocci, the most important being the *Streptococcus acidi lactici,* which is always found present in milk drawn direct from the teat.

This organism is extremely delicate, and can be killed by a temperature of 140° F. It grows best at summer temperature, 65° F., and develops rapidly, feeding upon the lactose in milk, and producing a considerable amount of acid. Up to a point the more acid it produces the better it grows. Being a coccus it forms no spores, consequently if it is killed by heat it will not continue to grow.

Now the putrefactive organisms, such as the colon bacillus, the bacillus of dirt, and others of this group are all killed by an exposure for ten minutes to a temperature of 180° F. They grow well in neutral solutions, but not in acid. The temperature at which they grow best, like all bacteria, is summer temperature, and, what is most important, they reproduce themselves by means of spores. As they will not, however, grow in an acid medium, we see that if the *Streptococus acidi lactici* is growing strongly, the putrefactive organisms cannot grow by reason of the acid manufactured by these streptococci.

The presence of the ferment in milk is an additional assistance to the lactic acid organisms, because the ferment starts the acidity of milk by the formation of lactic acid from the lactose. The acidity continues low in milk for about eight hours, but then rapidly rises owing to the acid output of the *Streptococcus acidi lactici,* which at normal temperature attains its maximum development in this time.

It will be seen then that the putrefactive organisms are held in check so long as the *Streptococcus acidi lactici* continue to grow. Suppose then this organism is killed by means of heat; at the same time the putrefactive organisms will be destroyed, but not their spores. These spores then will be left to grow into mature bacilli, unchecked by the organisms, the cocci, which have been killed and have no spores with which to reproduce themselves. Therefore, milk that has been contaminated by putrefactive organisms is rendered even more dangerous to infant life by boiling. Boiling, therefore, should never be resorted to with the idea of making the milk safe.

We have to remember the possibility of other organisms than the putrefactive being present. These are those of tuberculosis and the infectious diseases, such as typhoid, scarlet fever and diphtheria.

Taking tuberculosis first. Shall we necessarily boil our milk? The tubercle bacillus is mostly distributed by means of dust. It is a spore-bearing bacillus, and although somewhat resistant, yet it can be killed by heat or by drying, but the spores are most resistant to both drying and heat.

Its usual form of distribution is in dust, and this being air-borne may fall into the milk; but the milk is acid by reason of free lactic acid, and this acid inhibits the growth of the tubercle bacillus, consequently the spores do not develop readily on account of this acid milk being but a poor medium to grow in. It is also possible for the tubercle bacillus to enter the milk directly from a diseased udder, but precautions against this are taken by regular examinations of our cattle throughout the country, any cows showing symptoms of tuberculosis being rigidly excluded from the herd.

There is a third possibility—namely, that the tubercle bacillus may enter the milk from the blood. I mean that a cow may be tuberculous, although not showing tuberculous disease of the udder, and it is possible that such a cow may give milk in which tubercle bacilli are found which have found their way into the milk from the blood.

I admit this is extremely rare, but tubercle bacilli have been found in the blood of tuberculous mothers and of tuberculous cows.

On the face of it then it might seem that on account of the prevalence of tuberculosis we should boil our milk, but against this is the fact that it is extremely rare to find in the first year of infant life tuberculosis starting as a primary infection in the stomach or intestine.

Being air-borne in the dust, the tubercle bacillus is almost universally found to start disease in the air passages. With but few exceptions in the post-mortems that I have made upon infants in the first years of life, the original site of the tuberculosis infection has been in the bronchial glands—that is, the tubercle bacilli have been inhaled into the lungs, have passed into the lymph, and have been caught up by the first glands they met. The figures of my post-mortems conclusively prove this, and coincide practically identically with those of Professor Holt. Consequently, the conclusion I draw is that Nature protects the milk from the tubercle bacillus, and that, provided care is exercised in examining our cattle and in collecting and distributing our milk, there need be no fear of producing tuberculosis in infants by feeding them upon raw milk.

Now the infectious diseases, typhoid, diphtheria, and scarlet fever, when they occur in epidemic form, undoubtedly are spread through the milk. But these epidemics have usually been traced to their origin from one particular dairy, and it has been found that even the most elementary precautions have been omitted in the collection of the milk, as, for example, the milk-pails have not been scalded with boiling water or nascent steam, but have been simply washed out with water drawn from a well. This well has been found to be close to a cesspool or an ordinary farmyard midden. Or, as another example, the milkman has been found to have cases of diphtheria or scarlet fever in his own house. His hands and clothes were, of course, teeming with the specific organisms of these diseases; he consequently infects the milk he distributes, and as a result an epidemic has been started.

To my mind, this is no argument for boiling milk persistently. Of course, in an epidemic, until the source of the epidemic has been discovered, it is right and necessary that the milk should be boiled, but all that I have said points to the need for greater care in the collection of milk at its source, and greater care in its transit to and distribution in our populous centres.

From the point of view of the organisms in milk then, the effect of heat is adverse to the welfare of the infant. We still have to consider the action of heat upon the various constituents of milk: the fat, lactose, proteins and salts.

The fat of cow's milk contains a number of volatile fatty acids and a certain amount of fatty acid bases. These are split up by heat, and it is possible they are thus rendered of less service to the infant, and they certainly cause indigestion by acting as irritants in the digestive tract.

Lactose is unaltered by moderate heat, but by long continued heat is converted into caramel, which does not affect its value as a food, but materially spoils the look of the milk by turning it brown.

The effect on the proteins we already know. The whey proteins are mostly coagulated and rendered difficult of digestion; the caseinogen is unaltered.

The salts are considerably altered, and although they are present in small quantities, yet the effect on the individual is most serious, principally by reason of the conversion of the calcium salts into an insoluble compound, and the same with regard to the soda salts.

The chloride of soda is most essential to life in order to assist osmosis—that is, to allow of the passage of fluids containing nourishment through the walls of the cells. The calcium salts are necessary to the infant for the manufacture of bone, and for the proper functioning of the blood.

Consequently, on account of its action on the various constituents of milk, heating of milk is again emphatically against the interests of the infant.

In addition, we shall learn a little later that certain diseases, as rickets and scurvy, are largely due to the persistent use of boiled milk as the sole diet of infants.

On every count then it is apparent that fresh unboiled cow's milk, where human milk is unsuitable, should be used as infants' food; it should be neither boiled nor sterilized as a routine practice.

CHAPTER III

(*a*) BREAST-FEEDING

(*b*) BOTTLE-FEEDING

HAVING thus arrived at a clear understanding of the constitution of milk and its behaviour towards various reagents, we are now in a position to turn to the feeding of our infant.

At birth the mother's breasts contain no milk, but a fluid known as colostrum, containing a little fat, a little sugar, and a great deal of protein in the form of dead cells from the ducts of the breast gland.

It is not until the third day that milk is secreted, and not until the end of the first week that the regular flow of milk can be depended upon.

Now in the first twenty-four hours of its life the infant requires no food other than this colostrum; if it is fretful and apparently hungry, it is a mistake to give any cow's milk, for its requirements can and should be satisfied by small feeds of plain sugar and water, in amount not more than one tablespoonful at a time.

At the same time the breast should be used from four to six times in the first twenty-four hours, more frequently in the second twenty-four hours, and when the milk comes in on the third day the infant should be put to the breast every two hours. It should be allowed to remain at the breast not more than ten minutes for each feed.

The care of the breasts is a most important point at this time. The nipples should be thoroughly washed after each feed with hot water which has been boiled; they should be carefully dried; and then wiped over with some spirituous application. A useful preparation for this purpose is eau-de-Cologne and glycerine, mixed in equal proportions. This should keep the skin of the nipples healthy and hard, which will prevent the formation of an abscess in the breast.

The regular habits necessary to the well-being of the infant must be started from the first.

Every two hours the infant must be put to the breast during the day; even though it is asleep it should be aroused when the time comes round for a feed. At night two feeds—that is, at an interval of three or four hours—may be allowed after the first fortnight, and at one month one feed only in the night should be given.

In addition to the regular habits of feeding, the regular habits of evacuating the bowel should be inculcated into the infant from its earliest days.

The number of feeds for the first three months of life should be ten in the twenty-four hours at intervals of two hours during the day; three or four hours during the night. From three to six months the intervals should be two and a half hours during the day, five hours during the night; and from six to nine months the intervals should be three hours during the day and a six-hour interval at night.

All being well the infant will continue to thrive, gaining about 7 oz. a week after the first week. During the first three days of life it loses weight, and should have regained this loss at the end of the first week. Then the steady increase of 6 to 7 oz. per week is to be looked for. This should go on regularly up to nine months.

At this time, or possibly a little before, it will be necessary to add some form of carbohydrates to the milk feeds. Carbohydrates can be administered in the shape of barley water, Robb's biscuit, or glucose —which last is a liquid substance prepared from pure starch—is, in fact, a partially digested form of starch, and therefore eminently suited to the weak digestion of an infant.

At nine months the infant should be weaned from the breast and given a milk mixture consisting of two or three parts of cow's milk and one part of sugar water, together with some starchy food such as I have indicated. The feeds will be given at intervals of three hours, in amount 6 to 7 oz., no more than three feeds in each day to contain starchy food.

At ten months the strength of the milk mixture should be increased to three or four parts milk to one part sugar water, and as well bread should be given either in the form of a crust to chew, or as bread and butter, and, if the infant will take it, mixed with gravy as a meal when no milk food is given. Floury potato is an excellent form of starch. This with a little breadcrumb and gravy makes an excellent midday meal. At this meal water and not milk should be given to drink. And here a word as to the value of meat extracts.

Meat extracts such as Bovril, Liebig's, Valentine's, Brand's meat juice and gravy are not to be looked upon as foods. From the point of view of food value they are practically useless, but their use in feeding is to stimulate the cells of the body to do their work. Hence it is often necessary to give the meat extracts quite early in the infant's life in order to stimulate the cells to take up more nourishment. In this case it is given freely diluted and added to one or more milk feeds during each day.*

This description of the feeding of the breast-fed infant is applicable to a large proportion of our infants, but it is everyone's experience that we are not so fortunate as to find every infant suited by its own mother's milk. The mother may become ill, the breast milk may not be sufficient, or may actually fail. We shall find the infant is not getting on; it is fractious, cries a lot; has irregular, curdy, and frequent stools; or may be constipated or exhibit much vomiting.

From any or all of these symptoms we conclude that the breast milk is unsuitable. What have we to do? We have to fall back upon cow's milk; but this, as we know, must first be modified in the way already described. First, however, let us consider the dangers of giving too much or too little of the fat, carbohydrates, or proteid elements.

Firstly, fat. Fat can be taken in very large quantities, but many infants show difficulty in digesting fat in any quantity. In some indeed fat acts as an actual poison. What are the symptoms then of too much fat? First, vomiting; secondly, drowsiness.

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* Thus: Bovril 1 teaspoonful } Of this 2 teaspoonfuls to
Boiled water 8 tablespoonfuls } be given in 3 milk feeds

The infant may be too contented, or may be with difficulty aroused. Thirdly, there is diarrhœa with copious greasy stools; and fourthly, the colour of the child changes from the healthy pink to a peculiar primrose yellow tint. When this tint is present it is most characteristic; it is a grave sign pointing to the child being extremely ill from fat toxæmia, and if not relieved may end in death. Nature's effort at relief is by vomiting, diarrhœa, and refusal of food. When these symptoms occur it is essential to assist Nature by limiting the amount of, or even cutting off, all fat in the food.

The dangers of too little fat are obvious. The child will not grow, is fretful, not satisfied, always crying for its bottle, and tends to get cold.

The proteids I take next, partly because of their importance in the modification of cow's milk, and secondly, because the majority of cases of indigestion owe their origin to too much protein in the milk modification. What are the symptoms of too rich a protein feed? Flatulent distension of the abdomen, pain, shrieking, with drawing up of legs, diarrhœa, frequent green stools, with curd present as white pips; occasional vomiting of great masses of solid curd, or frequent regurgitation of watery fluid with small curd after a feed. Too little protein is, I should say, very exceptional to find in the home modification of milk, but one must remember that the proteids are necessary to supply growth, and therefore loss of weight may be consequent upon too little protein.

This, I repeat, is exceptional as a cause of loss of weight. Indigestion caused by too much proteid is much the commonest cause of wasting. However, the possibility of causing damage by giving too little protein must be borne in mind, for if this deficiency is allowed to continue for any length of time, a point is reached when the infant becomes incapable of taking up any nourishment; and, no matter how it is fed, the infant will starve to death, having lost the power of absorption.

With regard to the lactose, excess of this in the food produces a large amount of fermentation, and consequently flatulent distension, frequent acid stools, with soreness of buttocks and much fretfulness of the infant. Too little lactose renders the infant incapable of developing warmth; it is always cold, especially in its extremities.

Having premised so much, we can now discuss the modification of cow's milk to fit in with an infant's requirements, say three months old, which is suddenly deprived of its mother's milk.

It will assist us to again contrast the standard composition of mother's milk at the third month of lactation with that of cow's milk.

These are:—

	Cow's Milk.	*Human Milk.*
Fat ...	4·00 per cent.	4·00 per cent.
Lactose ...	4·50 ,,	6·50 ,,
Whey proteins	1·00 ,,	1·00 ,,
Caseinogen ...	2·75 ,,	0·50 ,,
Mineral salts	0·75 ,,	0·25 ,,
Water ...	87·15 ,,	87·25 ,,

A mixture containing three parts of fat whey, one part of whole milk, and one part of sugar water, five parts in all, gives us the following composition of this modification :—

Fat	$\frac{4}{5} \times 4{\cdot}00 = 3{\cdot}25$	per cent.
Caseinogen ...	$\frac{1}{5} \times 2{\cdot}75 = 0{\cdot}55$	„
Whey proteins	$\frac{4}{5} \times 1{\cdot}00 = 0{\cdot}80$	„

which fairly accurately fits in with our requirements. The fat and the total proteins are a trifle below our standard, but from experience I can say that this mixture is quite strong enough for an infant of three months. It is well not to give too large a feed at first—4 oz. at intervals of two hours, increasing to 5 oz. at two-and-a-half-hour intervals will be the correct treatment.

Knowing then the symptoms to look out for, one should watch the effect of feeding our infant upon this substitute feed. The first thing possible is that the infant is not satisfied. Obviously the remedy is to increase the total amount, giving 5 oz. in each feed instead of 4 oz., but leaving the proportion strictly the same.

On the other hand, the mixture may be too heavy; the infant takes badly—will not finish the feeds. We should then increase the sugar water and reduce the whey, our mixture then reading :—

Fat whey	2 parts
Milk	1 part
Sugar water	2 parts

Of this we should give a 4-oz. feed at first, and then later go back to the stronger mixture.

If, however, in spite of taking well, the infant does not thrive, then it is probable that we are diluting too much. We can leave out a little of the sugar water, the other two constituents remaining in the same proportion to each other, or we can add more fat whey, which, of course, dilutes our caseinogen, but increases the percentage of fat and whey proteins. Or we can increase the amount of whole milk, thus making the mixture richer in fat, whey proteins, and caseinogen.

It is purely a matter of observation and ordinary intelligence to modify cow's milk on these lines to fit an ordinarily healthy baby.

Having got a suitable feed, we next fit it to its increasing requirements, so that—say at five months—it is taking a 5-oz. feed of a mixture of two parts fat whey, two parts milk, and one part sugar water, and at six months it will probably take well a mixture of milk and fat whey of equal parts, 6 oz. in all.

This mixture will probably satisfy it until nine months, but if it be a hungry, strong baby, it may be found that it is not satisfied, and we can then increase the amount of the caseinogen, so that our feed reads :—

Milk, four parts; fat whey, three parts in a 7-oz. feed, or stronger still : two parts milk, one part fat whey. And then between eight and nine months, remembering the relative disappearance of whey proteins in the mother's milk, we can leave off our fat whey altogether and give a milk mixture of milk three parts, sugar water one part, 7 or 8 oz., and begin the addition of carbohydrates to the feeds by means of a solution of starch, such as barley water.

What I like to do is to use barley water as a diluent for three feeds in place of the plain sugar water, the barley water being prepared in the following way :—

One level tablespoonful of prepared barley, mixed cold, is stirred into one pint of boiling water. Boil this for twenty minutes and leave to settle. Make up to one pint again by the addition of boiling water, add three lumps of sugar or one tablespoonful of lactose, and boil again for a few minutes, then strain through muslin. Three or four tablespoonfuls of this should be added to three feeds during the day, thus: Milk, nine tablespoons; barley water, three tablespoons, or milk, ten tablespoons; barley water, four tablespoons.

At about nine months the carbohydrate constituent is further increased by the addition of Robb's nursery biscuit, beginning with one-third of a biscuit with three feeds in a day.

The best way of preparing the Robb's biscuit is to break it up in a saucer, pour enough boiling water upon it to make it into a paste, then add some of the milk feed already prepared, leaving the child to drink the remainder of the milk feed either from a cup or bottle. It is well, however, to encourage the child at this age to drink from a cup.

The feeds then will be: an early feed of milk and water at about 6 a.m., 8 o'clock a feed with Robb's biscuit, 11 o'clock plain milk and water. Then the infant should sleep until 1.30 to 2 o'clock, when it will be given another milk feed with Robb's. At 4.30 to 5 o'clock another feed of milk and Robb's, then at about 6 o'clock it has its bath and is put to bed. Just before being put to bed it will have one small feed of milk and water, and at 10 o'clock the child should be picked up and made to pass water, when it will also require a small drink of milk and water. Up to the age of fifteen months the child will take this last feed; after this age, however, it no longer requires it, and consequently it is better omitted.

Throughout these feeds are of the strength three or four parts of fresh milk, with one part of sugar water, the total amount at each feed being 6 or 7 oz. In my experience milk should always be diluted with some water.

As the child grows its appetite increases; it will want something more added to the 8 o'clock and the midday meals. A dry crust at first, then a small slice of bread and butter should be given it to chew as part of the 8 o'clock feed, and also at the 5 o'clock feed. At about ten months, or in a very vigorous infant at nine months, a tablespoonful of floury potato can be added to or take the place of Robb's biscuit with the midday feed; if not satisfied, a small slice of bread and butter should be given in addition. At ten months the milk in the midday meal may be omitted, and a meal of breadcrumb, gravy and potato should be given. It is possible that the child will at first dislike the taste of gravy with the potato. It is often found that the potato and breadcrumb, or even potato and milk with a little salt is well taken, and the gravy will be drunk out of the drinking cup, where it would not be taken if poured over the potato. A child at this period frequently learns to show its likes and dislikes. It sometimes happens that for a time it has taken gravy well, it then suddenly refuses this without apparent reason.

It is well to remember this, because of the importance of the starchy food in the child's dietary. If the gravy and potato are refused, by giving the two separately it often is found that the potato is readily taken, whereas the gravy is left. Of the two elements of the meal the potato is a long way the more important.

Up to fifteen months it is quite sufficient to feed the child in this way, increasing the starchy constituent by extra bread and butter, giving a midday meal, as already described—the bread, gravy and potato—but alternative meals should be commenced during this period. For instance, children are extremely fond of milk pudding, such as rice or tapioca, or semolina made with milk and thoroughly cooked. The various custard powders, such as Bird's or Foster Clark's, are excellent starchy foods, and with milk will make most agreeable puddings for an infant. It is, however, well to remember that a one-course meal is preferable, and therefore the milk pudding should constitute the whole meal. It must not be forgotten that water should be given to the child before or at this meal; on no account should milk be given as a drink, either at this meal or in between meals.

At fifteen months the child will probably require still further variations in its diet. With healthy digestion an egg boiled for three minutes makes a good substitute meal for the other two we have previously given at midday. It is not wise to feed children of this age at the 8 o'clock meal with an egg; it is preferable to make it a special meal for the midday, and then only occasionally. At about fifteen months with the 8 o'clock feed we can add to our carbohydrate constituents by giving a small portion of well-cooked porridge. The best porridge is coarse oatmeal, which should be cooked in a double saucepan overnight, and again thoroughly warmed through in the morning. This ensures all the starch granules being broken up and the meal being easy of digestion. The porridge should be spread out on a plate, a little sugar should be added, and some of the milk prepared for that meal added to it. It will be obvious that with porridge there will now be no need for Robb's biscuit.

At about eighteen months, in addition to the porridge, a little fat bacon cut from a piece of boiled bacon, cold, should be given with bread to the child at the 8 o'clock feed. To the dinner, or midday meal, a little freshly cooked meat, well cut up, can be incorporated with the potato and breadcrumb; in addition, other vegetables, such as cauliflower or young peas, well cooked and mashed, may be added. In season, French beans or a little spinach, or the leaf of very young cabbage may also be given. But children are not very fond as a rule of these vegetables, and one should go slow in adding them to their meal, because they are so easily put off the food-stuffs that are necessary to them.

Further, fish boiled, or better still, simmered in milk and water, can now be given as a change of diet in place of the meat or egg for the midday meal. Potato should still be given with the fish, and it is now permissible to give two courses at this midday meal, the first course consisting of gravy, meat and potato, or fish and potato, followed by a second of milk pudding with the juice from stewed fruits. Fruit juice is of great value to quite young infants. It is necessary to infants suffering from certain diseases, such as rickets and scorbutus or scurvy, and to the healthy it is a pleasant and useful adjunct to their meals. The best way of giving fruit juice when we have fresh fruit in season is to take a mixture such as rhubarb, gooseberries, strawberries, cherries, currants; stew well with sugar, and strain through muslin. This fruit juice makes an agreeable second course of the midday meal, with or without a milk pudding, junket or custard (not egg custard). When these fruits are not in season there are others, as apple, blackberry, and grapes. These again can be stewed, but probably apple is nicer if stewed alone, and this need not be strained if the fruit is properly cored and peeled before cooking.

At eighteen months, having nearly arrived at the ordinary mixed diet of adults, it is not necessary to give—in fact, it is better to discontinue—the milk feeds at 6 a.m. and 10 p.m.

The first meal should be the 8 o'clock; it is good to give a small drink of milk and water at 11 o'clock.

The midday meal comes after the child awakes from its mid-morning sleep, then after that nothing until the tea or final meal at 5 o'clock. On going to bed about 6.30 p.m. a small drink of milk and water should be given, but if anything is asked for at 10 p.m. when the child is picked up before finally settling for the night, it is good to give a drink of plain water only.

This constitutes the normal feeding of a normal infant. We should also know its normal length and weight, because these two are an important guide as to whether or no the feeding is satisfactory.

The normal length of a full-grown infant at birth is 21 in., measured down the back from the occipital protuberance at the back of the head to the heel. The tape should not be stretched, but should follow the curves of the body at the neck, round the nates, inside the bend of the knee down to the heel. Up to six months it should increase in length at the rate of 1 in. a month, at six months then it is about 27 in. In the next six months it increases at a slower rate, about 3 in. more in all, so that 30 in. is a fair average length of an infant twelve months old. From this time onwards its increase in length is about 3 to 4 in. a year.

Now the weight at birth is about 8 lb. After the first week, when the weight is roughly identical with what it was at birth, the normal rate of increase is 5 to 7 oz. a week. This should be expected in a normal healthy child. At six months the weight is double what it was at birth, and at one year is trebled. 8 lb., 16 lb., and 21 to 24 lb. are the weights we should expect at birth, six months, and a year respectively.

As in the case of the rate at which a child grows, so the putting on of weight is inclined to lag behind towards the latter months of the first year, and still further to lag behind during the second year.

At the age of 2 the weight will not be double what it was at twelve months, but probably only 15 to 18 lb. more—that is, the child will weigh 35 to 38 lb.

This then is the method of feeding a normal infant, and if carefully followed the results should be satisfactory.

PART V

ABNORMAL INFANTS

CHAPTER I

DIFFICULT INFANTS

(*a*) *Congenital Defect*
(*b*) *Atrophy*
(*c*) *Pyloric Stenosis*

HAVING completed our consideration of the feeding of normal infants, we next have to consider the management and feeding of the difficult babies, those whose start in life is abnormal.

First, there is the premature infant which may have been born in the seventh or eighth month.

Then there is the infant suffering from congenital defect, born at full time, but equally as delicate as a premature infant. It is congenitally immature, or owes its defect to congenital disease, *e.g.*, syphilis.

Secondly, there is the marasmic, atrophic, or wasting infant, whose start in life was normal; it developed normally for a time, but then began to fail and waste.

Thirdly, there is the infant suffering from pyloric stenosis.

It is well to take these types of infants together, for they are all most difficult to feed, and they all will die unless certain golden rules are followed.

These are: keep them warm, give plenty of oxygen, keep them at first rigorously on a low diet.

These infants tend to get cold and have very little power of getting warm themselves, consequently it is necessary to keep them in a room over-warm, or, in the case of a very frail premature infant, in an incubator.

An incubator is, however, only to be used for a very short time. As soon as possible the infant should be taken out repeatedly each day and aired in a well-warmed, well-aired room.

It is preferable to make use of a room that can be given up entirely to the infant. It should be kept at a constant temperature of 70° F., and should be capable of having its air constantly changed.

I cannot too strongly insist upon this point, because one so frequently sees warmth produced by stopping up every inlet and outlet of air. This should never be done. The room should be made warm by a coal fire, and the windows should run right to the top of the ceiling, and be capable of being opened top and bottom. The cot in which the baby lies should be placed so that no draught blows on it. Further, to increase the warmth of the infant's body it should be swathed in cotton-wool, not only the trunk, but the arms and legs; and it should not be forgotten that the daily bath, if given, should be of brief duration, and in a room even warmer than 70° F. A very delicate or premature infant should, however, never be bathed until it shows a decided improvement in its vitality. As soon as the bath is finished the cotton-wool should be re-applied, and care must be taken that the cotton-wool is dry. It should, in fact, have been aired in front of a fire for some little time before its use.

The oxygen is supplied by means of the good ventilation which we have seen is necessary for our room, but in addition pure oxygen should be at hand in a cylinder, and can be administered for periods of ten minutes at intervals of about six hours or, roughly, four times a day. Oxygen is one of the finest stimulants to delicate infants. It should be administered warm, and this is easily done by leading the tube from the oxygen cylinder through hot water at a temperature of 120° F. before it arrives at the infant's mouth.

A simple apparatus consists of two separate yards of rubber tubing and a two-foot length of soft lead piping, which can be curled up by about three turns into a convenient form for immersion into a vessel containing hot water. The parts are fixed thus: One piece of rubber tubing should be attached to the oxygen cylinder by one end, and to the other end is fixed one end of the lead piping. To the other end of this the second piece of rubber tubing is attached, and at the terminal end of this there should be a small glass funnel in order to distribute the oxygen over the face of the child. The lead piping dropped into water at 120° F. will rest on the bottom of the vessel owing to its weight, and thus oxygen arrives at the face of the child warm and not cold.

We will now consider the feeding of the first two groups, the immature infants and those suffering from congenital defect.

The feeds we have seen should be low, and especially in the fat and caseinogen elements. Nothing is more easy than to set up indigestion by failure to observe these rules. In addition, the extreme delicacy of these infants in withstanding the acid of cow's milk must be remembered. Any slight error in diet is sufficient to set up diarrhœa, and where the vitality of the infant is so low a fatal result is almost certain.

In the immature infants the degree of the immaturity should be our guide as to diet and prognosis.

Many are so poorly developed that they are incapable of assimilating any food whatever, either breast-milk or artificial feed. They just live on their own tissues, and as these become used up they gradually dwindle and die. The stronger—those more nearly approaching the normal size—can, however, be gradually nourished. Their development is slow, their requirements are small; but eventually a stage is reached when almost normal rate of growth and appetite appear, and then full feeds can be given with excellent results.

For these a milk prescription to begin with should read :—

	Fat	Lactose	Fat Whey	Caseinogen	Alkalinity
Per cent. ...	1·00 ...	5·00 ...	0·45 ...	0·15 ...	10

Or in home modification a milk mixture of three parts fat whey, one part fresh milk, eight parts lactose water will give about the right proportions, and the alkalinity would be made correct by the addition of a dessert-spoonful of lime water to each feed.

As the infant thrives the strength of the feed should be gradually increased by lessening the amount of water, the feed still remaining from 2½ to 3 oz. in amount, and the intervals one and a half to two hours.

Should, however, the feed produce diarrhœa or scalded buttocks, we must at once modify it, and preferably by means of heat. By heating the feeds to a temperature of 150° F. for ten minutes we destroy the acid-forming organisms and the ferments in the milk; this will stop any increase in acidity, and it may be that by this simple procedure a feed which previously disagreed now suits the infant. We can, in addition, add more lime water, or to each feed add 2 or 3 gr. of citrate of soda. This will still further reduce the excess of acid in the milk.

The heating, however, should not be continued indefinitely, but as soon as the infant appears to be established on this heated feed, the best course to follow is to give feeds alternately heated and unheated, gradually in this manner educating the infant to take all feeds unheated. In the same way the citrate of soda should be discontinued, otherwise the normal faintly acid reaction of the intestinal contents will be changed to alkaline; this will greatly add to our dangers by allowing rapid growth of the organisms of putrefaction.

Alternative feeds to these are peptonized milk diluted with an equal quantity of sugar water. Or a dried milk feed, such as Nestlé's "Ideal" milk, diluted in the proportion of one part of the milk to ten or twelve parts of sugar water.

This latter feed is weak in fat and protein elements, and contains no added sugar. Some must therefore be added, and this is done by diluting the milk with sugar water prepared in the way already described.

Peptonized milk is made by first diluting fresh milk to the required strength, then adding one tube of peptonizing powder to each pint of mixture and warming this to a temperature of 100° to 105° F. by standing it in a hot-water bath. The peptonizing process should at first be continued for thirty minutes, and then checked by raising the temperature of the milk to 150° F. for ten minutes.

Later, by shortening the time of peptonizing, the milk can be less thoroughly peptonized, and gradually the infant can be trained to take a raw milk mixture. It will then be found that the addition of the whey proteins increases its rate of progress.

Yet another alternative feed is introduced by the substitution of liquid glucose for the sugar in our sugar water, and it appears to improve many infants of this type which do not readily assimilate any food. Liquid glucose is a commercial preparation used in brewing, which is formed by the action of heat upon starch. It is therefore a starchy food, and is in a condition requiring no digestion.

It can thus be absorbed by the infant, and forms an excellent substitute for the sugar of milk. It should at first be given in strength one tablespoonful to one pint of boiled water, using this as the diluent of our milk in place of sugar water. It may also be used as a feed alone for several feeds in stronger solution—namely, three or four tablespoonfuls to one pint of boiled water.

By ringing the changes on these various feeds, these delicate infants can be led to a point when development progresses normally and uninterruptedly on a more or less normal feed. Only it cannot be too often insisted upon that any set-back must at once be met by reducing the strength of the feed; in other words, going back and beginning all over again.

My practice is to have a list of the feeds kept on one large sheet of paper, so that at a glance one can see a suitable change feed that has been successful for a time at some earlier period in the infant's history to which one can revert.

As to drugs, only a very few are of the least use. Strychnine as liquor strychninæ hydrochlor. of the British Pharmacopœia in minute doses is of some value; digitalis in the form of digalen is also good in many cases. A useful prescription is one drop of each three times daily continued for about a week. But if the infant becomes restless the strychnine should be discontinued. A very useful stimulant is opium in fractional doses. The compound tincture of camphor contains a small amount of opium, and drop doses of this preparation three or four times daily produce extraordinary improvement in these delicate babies. Besides the stimulating effect, there is also the soothing and constipating effect of the opium in this preparation; the infant sleeps better and also has less frequent stools. It is therefore a most valuable ally, and can be safely given to the tenderest infant in these doses.

Alcohol in the form of brandy is also indicated where the infant is always cold. Four or five drops in warm sugar water should be given at intervals of four or six hours. It is better to give it thus separately than to incorporate it in the infant's feeds.

As regards congenital syphilis, it is, of course, essential that a correct diagnosis be made so that suitable remedies may be given as soon as possible. What are the striking features of a syphilitic infant? First and most important its cry. This is a constant, weak, persistent bleating; quite unlike the loud, angry cry of a hungry infant or the shrieking of one in pain. It is unending and apparently so purposeless that it has been described as "that mad cry." Coupled with this will be signs of immaturity—shortened length, 20 in. or less, abundant hair coming far forward on the forehead, and in some a peculiar ashen colour of the skin. These infants are always extraordinarily hungry. They are never satisfied, the mother will say. After six or eight weeks of life constitutional signs of the disease appear. First a rash on the trunk, arms and legs, usually in the form of separate raised blotches of a peculiar dull red colour, which fade on pressure, but show a characteristic fixed yellow in the patch thus pressed upon. Later the patches scale, or even the skin itself desquamates in large flakes without any definite rash. Other signs will be ulcers, usually on the hard palate, and more rarely in the angles of the mouth and nose. A frequent sign of syphilis is the snuffling breathing with copious nasal discharge. Of later signs, the most common are abscesses on the buttocks and frequently in the scalp. These first make their appearance at about the sixth month. Coughing is a frequent symptom. Often the infant is said to have been born with a cough.

It is then most important to recognize the early signs of this disease so that treatment may be begun at once.

Mercury should be administered by the mouth, and is most conveniently given in tablets of grey powder, hydrarg. c. cret. $\frac{1}{3}$ gr. three times daily. As the infant grows, and it is extraordinary how soon it responds to treatment, these tablets should be increased to four and then six daily.

They should be continued for at least three months, may then be discontinued for one month, when a second course of three months' duration is given, and so on with intervals of one month's rest throughout the first year. During the second year three courses of two months' duration with two months' interval between each will complete the cure.

It sometimes happens that mercury cannot be tolerated by the mouth, and then it is advisable to change to inunction of the skin. The oleate of mercury ointment of a fixed strength—10 per cent.—should be used, and of this not more than one teaspoonful should be rubbed into the skin of the abdomen once daily.

We now turn to the marasmic infant—that is, an infant suffering from wasting, atrophy, or malnutrition. Whichever name is applied to this condition, it must be remembered that it is an acquired disease and not a congenital defect. A typical picture of an advanced case is that of an infant fully developed as to length—21 in. or more—but with tissues shrunk and skin hanging in wrinkles, exactly resembling a toothless old man. The history of such a case is that it was a fine baby at birth; it developed normally upon the breast-milk, but this failed, and from that time the infant did not get on. All sorts of feeds were tried without success. After remaining more or less stationary in weight for some little time it began to waste, and then lost weight rapidly towards the end. Post mortem the appearances are always the same—namely, a chronic ileo-colitis, or inflammation of the lining membrane of the small and large intestines.

There is little or no alteration in the stomach, some excess of mucus sticking to the wall, and patches of congestion.

The intestinal walls are obviously thinned, so thin as to resemble tissue-paper. Near the pylorus the interior of the bowel looks normal; lower down the bowel patches of congestion become frequent, and are most marked at the termination of the ileum near the ileo-cæcal valve. In addition, the patches of lymphoid tissue stand out prominently, congested, and sometimes bleeding. In the large intestines the mucous membrane presents a peculiar mouse-eaten appearance which is quite characteristic; small punched-out depressions which are, however, not real ulcers, but apparently abrasions of the surface epithelium only, not extending to the deeper tissues.

Under the microscope the changes seen are general loss of surface epithelium, and also of the cells lining the glands; in addition, there is a small-celled (leucocytic) infiltration between the glands which does not invade the muscular or outer coats. This small-celled infiltration is characteristic of inflammation, and from these cells fibrous tissue develops, contracting and strangling blood-vessels and glands.

The pancreas to the naked eye appears healthy, but microscopically the same inflammatory condition is found; a small-celled infiltration between the glandular elements is seen.

The mesenteric glands are red and swollen. The liver is fatty, also showing increase of the connective tissue cells.

Now all these signs point to definite long-continued irritation, and the irritant can be nothing else but indigestible masses of food, or the toxins produced by the action of putrefactive organisms on these masses in the intestines. It is clearly then an acquired disease. Further, it is evident that in long-continued cases there is very little chance of recovery of the infant, for the small-celled infiltration would go on to the formation of fibrous tissue which would strangle and cause the death of these glands, which normally secrete the digestive juices. Before this stage is reached, however, the infant dies from inanition. For consider what has happened. The cells lining the intestinal walls are wasted and presumably cannot function. We have seen that this function is to secrete secretin, a substance necessary for the stimulation of the glandular activity of all the glands which supply the digestive juices—namely, the isolated glands in the walls of the stomach and intestines, and the pancreas and liver. Further, it is obvious that all the glands are hampered by the leucocytic or inflammatory condition around them; consequently, thus hampered, they cannot but respond badly to a weakened stimulus. Or it may be presumed that, owing to bad food being given, food that the infant's digestive organs are quite unable to cope with, the cells, both those lining the intestinal walls and the glands, do their utmost to respond, but they become overworked and fail in the attempt and waste.

Whichever way one looks upon it, there can be no question but that a vicious circle is established, the cells waste, and there is less function performed; by reason of this there is less digestion, less food is assimilated, and consequently the cells do not receive an adequate supply of nourishment for their regeneration.

The balance, therefore, of the infant's nutrition is upset, all of the cells of the body become atrophied, and death ensues; there is no vitality left.

The treatment of this condition has already been discussed, as owing to the extreme delicacy of these infants they should be treated on the same lines as those suffering from congenital defect.

There is, however, one important point to remember—namely, the formation of toxins. These are the result of the action of the organisms of putrefaction upon masses of undigested food, and principally the protein element. It should then be our constant care to see that undigested curd is not allowed to accumulate in the intestines. This, of course, implies that our caseinogen element or raw milk should be given very sparingly, well diluted with fat whey and water; but in addition we can assist the infant by adding to the feeds pure cultures of the acid-forming organisms of milk—the *Streptococcus acidi lactici*. This will help the splitting up of the food-stuffs, and, most important of all, will render the contents of the intestine acid, thus inhibiting the growth of the organisms of putrefaction; for it will be remembered these cannot grow in the presence of acid. In addition, we should see that the lower bowel is kept clear by irrigation every second or third day, so as to ensure the removal of all undigested food-stuffs from it. When the irrigating fluid returns clear from the bowel we can leave off the irrigation, only occasionally resorting to it if toxic symptoms arise. These we shall discuss later under Intestinal Toxæmia.

To give a colon irrigation the requirements are: a soft rubber catheter, No. 12 to 14 English pattern, a glass tube for connecting this to one yard of rubber tubing, and a douche can or large glass funnel, to which this rubber tubing is attached.

A quart of fluid is to be ready, either plain boiled water or saline solution, made by dissolving one teaspoonful of salt in one pint of boiled water. The temperature of the solution should be 108° to 110° F., for, owing to the length of tubing, it is not much hotter than body temperature when introduced into the bowel. The method to follow for irrigation is as follows: Place the infant on its back wrapped in a bath towel and lying on another. Oil the catheter with salad oil, start the fluid running from the catheter by raising the douche can, and whilst the fluid is running introduce the catheter for about 2 in. into the child's bowel. The douche can should be raised about 1 ft., so that the flow of water has only a moderate pressure behind it. The rectum is thus made clear of contents. After this, and whilst continuing the washing, the tube should be steadily passed upwards some 8 or 9 in. In this way the undigested masses in the lower bowel are washed away, and the washing should be continued until the fluid returns clear.

It is seldom that an infant exhibits any shock from this or even objects to the process. On the contrary, it is usually rendered comfortable and happy. If, however, any sign of collapse occurs, and the infant gets cold and pale, then the irrigation should be discontinued; brandy five to ten drops in warm sugar water should be given, and the infant returned to its cot wrapped in a warm blanket, and outside this two hot bottles should be placed; oxygen, too, should be administered.

For the purpose of treatment, then, these difficult infants have been thrown into one class. But I have shown that marasmus or atrophy is not a congenital defect; it is an acquired disease—is, in fact, a living picture symptomatic of ileo-colitis, which we now know results from bad feeding.

We should then be familiar with the early symptoms of this disease in order to avoid the late fatal effects.

Firstly, too much of all the constituents, too large a feed, leads to distension of the stomach; Nature relieves this by vomiting. The stomach may empty itself by one large vomit, but if the food is not expelled in this way, by remaining in the stomach it becomes very acid, and the infant is then constantly regurgitating sour-smelling watery fluid. The vomit may therefore show two characteristics:—

(1) A large amount pumped up with large masses of curd, or

(2) A watery, sour-smelling fluid, with small, broken-up curds, small in amount, at frequent intervals.

The next symptom is diarrhœa—Nature's effort at removing the irritating undigested masses from the bowel. The stools become frequent, and change from the normal yellow pasty character to yellow and watery, with particles of undigested food and some mucus, a clear jelly-like fluid. Later the stools become green with mucus and curd. This colour means that the food-stuffs, and with them the bile, are hurried through the intestines too quickly. The bile is not given time to be altered in its passage through the bowel; it is extruded in practically the same condition as when it left the gall-bladder. Of itself this means necessarily no harm, but in association with the other symptoms it must be taken into consideration. Pain, evidenced by shrieking and drawing up of legs, will accompany this sign.

The colour of the infant is a most important sign of its health or otherwise. Normally the skin should be pink, almost transparent, but when ill there is pallor, the skin appears thick and somewhat muddy-looking; there may be also hectic patches of red on one or both cheeks.

Constipation frequently alternates with diarrhœa. Owing to the overloading the bowel has more work to do than it is able to cope with; stagnation is the result. The lower bowel, Nature's receiving tank, becomes distended with masses of imperfectly digested food-stuffs. In consequence putrefactive changes go on in the bowel with the formation of gas and poisonous toxins. There is much flatulence and discomfort. Then Nature relieves by an attack of diarrhœa, brought on by the irritating nature of the contents of the bowel.

It is easy then to understand how ileo-colitis is brought about, and by correctly reading the early symptoms this disease should be avoided.

The proper modification of fresh cow's milk, fitted to the requirements of each individual child, should be our constant aim. For it must be remembered that no two infants are similar. A modification of milk that suits one does not necessarily suit another. Each has to be looked upon as a study in itself, though not a difficult one where the physiological processes and requirements are known.

But, it may be objected, many infants appear to do well on one or other of the patent foods, and only in the later months fall off and get ill. It is precisely these cases of ileo-colitis which are found to have been fed persistently on one or other of the many patent foods or brands of dried milk, and are the most difficult to put right. The explanation, as I understand it, seems to be that Nature made the effort to digest this food, and for a time was successful; the infant thrived on the nourishment thus obtained. But a limit to the power of the cells being reached, they could not continue the effort, and wasting of these with loss of function resulted. Then followed the vicious circle and the chain of symptoms already described. But inasmuch as the cells have long undergone a strain they have been unequal to, so there is a high degree of wasting, chronic inflammation, and profound illness.

From this I learn that, though patent foods and dried milk may be found very suitable as a change feed, yet on no account is the infant to be fed for long on these food-stuffs alone. Nature demands a raw milk for its young, and it should be our care to conform to Nature's requirements at all times. Knowing, therefore, Nature's workings, the physiology and anatomy of the human infant, and the composition of its natural food supply, we should at all times do our best to assist Nature.

Our final study in this chapter is the infant suffering from pyloric stenosis. This begins as a spasmodic contraction of the pylorus, the outlet from the stomach into the intestine. It is always found in infants suffering from congenital defects; such an infant being under weight and under size, say 6 lb. at birth, 19 to 20 in. in length, and showing other signs of immaturity as the hairy scalp prolonged forwards down on to the face. The cause of this spasmodic contraction is probably undue acidity in the stomach in conjunction with an excessively sensitive nervous system. For normally the pylorus contracts when food enters the stomach, then opens to allow the passage of food into the intestines, being stimulated reflexly by the degree of acidity of the stomach contents. In these immature infants apparently the reverse holds good. A little food at first trickles through the pylorus; then, as the acidity in the stomach rises, the pylorus tightly contracts, nothing passes through. Consequently the infant begins to vomit—at first curds and acid fluid, but later simply the feed much as it was taken. No acid is formed to curdle it, as the stomach has become so irritable that food is at once rejected as soon as it is taken. Wasting is, of course, rapid, and death ensues from starvation.

Post-mortem, it is in my experience rare to find any real stenosis or contraction of the pyloric ring, though an organized ring of fibrous tissue does occur. I have found only one such in upwards of 200 post-mortem examinations. Surgeons, however, tell me it is relatively common. Certainly spasm of the pylorus is common, but the majority yield to treatment if commenced in good time. The symptoms of vomiting appear soon after birth, become pronounced by the end of the first month, and become progressively worse in the second and third months. It is unusual to see this condition later, as either it yields to treatment or is responsible for the death of the infant from starvation. With the vomiting there will be obvious peristalsis of the stomach—that is to say, on looking at the infant's abdomen as it lies on the nurse's lap, a rounded swelling appears just below the sternum, travelling downwards towards the right hip; it disappears opposite the umbilicus, and reappears again under the sternum. This process is repeated rhythmically, and is to be looked on as symptomatic of violent muscular effort of stomach or intestine to overcome obstruction. It is a mistake to cite this obvious peristalsis as diagnostic of pyloric stenosis, for it may be the large bowel violently contracting to overcome constipation.

A point to look for to clinch the diagnosis of pyloric stenosis is the presence of a lump in the region of the pylorus—that is to say, about 2 in. below the lower border of the right costal margin, and about the same distance to the right of the middle line. By palpating here a firm small lump may be felt, which is the thickened pyloric ring, and this, with the vomiting and obvious peristalsis, is diagnostic of real pyloric stenosis. In addition, the infant is always constipated, is wasting rapidly, and its colour and general nutrition are bad.

The treatment is divided into (*a*) medical, and (*b*) surgical. The only drug of any use is bromide of potassium in doses of 1 gr. every six hours. And the feeds must be small and low in caseinogen to avoid the production of any big curd in the stomach.

It is well also for a time to add citrate of soda 3 gr. to each feed, or if this is not sufficient to obviate vomiting, then the feeds should be peptonized. The size of the feeds is important: 1 to 1½ oz. should be given every one and a half hours, the amount of feed and the length of the interval between being increased as the infant shows improvement. As soon as possible the addition of citrate of soda or peptonizing should be stopped.

A modified milk feed suitable for these infants should read :—

	Fat	Lactose	Whey	Caseinogen	Alkalinity
Per cent....	2·00 ...	5·00 ...	0·75 ...	0·25 ...	10

Or in home modification :

Fat whey	6 parts
Milk	1 part
Lactose water	5 parts

If, however, there is definite evidence of an organic stricture, as shown by the presence of a lump on palpating the abdomen in the region of the pylorus, it is not likely that medical treatment will effect a cure. It is better, without waste of time, to have recourse to surgical treatment. This consists of opening the abdomen, opening the stomach, and stretching the pyloric ring, or by means of a gastro-enterostomy—that is, making an artificial communication from the stomach into the intestine—producing a short circuit round the useless pylorus.

The choice of anæsthetic is important, but under spinal anæsthesia, together with the inhalation of a little ether, these delicate infants appear to stand the shock of the operation wonderfully well.

CHAPTER II

THE TOXÆMIAS

(a) *Intestinal Toxæmia*
(b) *Fat Toxæmia*
(c) *Acidosis, or Acidæmia*

ACUTE intestinal toxæmia is our next consideration. It is a correct term for that disease known variously as summer diarrhœa, or epidemic or zymotic enteritis; for it at once discloses the fact that the disease is a general poisoning of the system from poisons produced in the intestines, and further, that the onset of the disease is sudden or acute. The disease occurs mostly in the third quarter of the year, that is, during the months of July, August, and September, and is practically confined to bottle-fed infants living in urban districts.

It is rapid in its course and extremely fatal, being responsible for from 20 to 30 per cent. of the deaths of infants in their first year. And the tragedy of this is that it is a preventable disease. It is not in any sense an epidemic disease, although the fact that so many infants living in the same area are attacked by it at the same time might lead to this conclusion.

It owes its origin to the poisonous products of the organisms of putrefaction upon the nitrogenous elements—the caseinogen in milk. These organisms as we have seen cannot survive in fresh uncooked milk, or, at any rate, are inhibited by the acid organisms, the bacillus and *Streptococcus acidi lactici*.

The fact that infants in urban life are fed on milk which has been boiled or sterilized under the mistaken idea that it is thus rendered safe for food explains the apparent occurrence of this disease in epidemic form. The fact that breast-fed babies do not exhibit this disease points conclusively to the cause being in the food of bottle-fed infants.

It will be useful to again consider the effect of heat upon cow's milk, as set out in the chapter upon that subject.

Here we learnt that raw milk contains delicate acid-forming organisms which inhibit the growth of the organisms of putrefaction.

If we boil or sterilize or scald milk we kill the delicate acid organisms. These are killed at a temperature of 140° F. The putrefactive organisms are also killed, but unfortunately possess spores which are not killed even by a temperature of boiling water (212° F.). Boiled milk, in which no inhibiting acid organisms exist, is a most suitable medium for the spores of the putrefactive organisms to develop in; food-stuff there is in plenty—namely, the caseinogen—and the temperature most suitable to their development is 70° F., or, in other words, our summer temperature. Consequently, in boiled milk, these spores of the putrefactive organisms are free to grow into mature bacilli, and to produce by their action upon the nitrogenous elements in the milk extremely poisonous substances which give rise to the symptoms of intestinal toxæmia.

Milk, then, even though it contains putrefactive organisms, is a safe food so long as it remains uncooked, but is very dangerous and poisonous if it has been scalded, sterilized, or boiled.

We also see, from the above, the reason for the great prevalence of the disease we are considering during the summer months. The temperature of the air at this time coincides with that most suitable for the growth of the putrefactive organisms, and it is at this same period of the year when there is so much trouble in keeping the milk. It is usually boiled to prevent its souring.

But these conditions should not arise. Our milk should be collected and distributed under very different conditions to those at present existing. What these are and how to alter them I put forward in Appendix I.

The symptoms of intestinal toxæmia occur in the following order: Vomiting, diarrhœa, collapse, pallor, an anxious expression of face, extreme restlessness, rapid wasting, coma and death.

A frequent history is that the infant had not been doing satisfactorily for some time; it had been bottle-fed, and many changes of food had been necessary. Ileo-colitis had been set up by unsuitable food. In this condition the infant is extremely susceptible to the poisons existing in its food. Its balance is already upset, its nutrition is low, and its powers of resistance are extremely small.

A typical picture of the disease is the following: After some hours of being out of sorts vomiting becomes urgent and acute. The vomit at first is curdled milk, then watery fluid, then nothing but constant retching. This in turn passes off and intense diarrhœa sets in. The diarrhœa begins by copious yellow, evil-smelling stools containing masses of curd. Later the evacuation becomes watery, of a dirty colour, foul-smelling, and very frequent. There is a constant desire to empty the bowel with little or no result.

In about two days time the child is gravely ill, very pale, with the peculiar abdominal expression; eyes widely open, skin much sunken around, and a very anxious, distressed look. All muscular power is gone, there is extreme restlessness of head and limbs as the child lies helpless, and the flesh has wasted to an alarming extent. Coma or unconsciousness comes on gradually, the child refuses to suck or swallow, and finally life ebbs away.

With regard to the diarrhœa, it must be remembered that this is not always a prominent symptom. Many infants exhibit signs of toxæmia without any diarrhœa—in whom, in fact, constipation exists throughout the illness. On the other hand, all cases of diarrhœa are not cases of toxæmia. Often the diarrhœa is due to too much acid being formed from the lactose in the milk. These cases show no symptoms of toxæmia, and are rapidly cured by omitting the lactose and substituting cane-sugar or glucose for sweetening purposes.

The treatment of intestinal toxæmia must be urgent and drastic. First remove the cause, and secondly, go slow in giving milk food. On no account attempt to treat symptoms of vomiting and diarrhœa by drugs calculated to check intestinal peristalsis. In these cases it is absolutely vital to get the poisons out of the system as quickly as possible. Nature's effort is clearly in this direction, as evidenced by the vomiting and diarrhœa.

Give then as soon as possible one teaspoonful of castor oil, and at once wash out the bowel with a colon irrigation. By the mouth give nothing except saline lactose* for the first twenty-four hours. The infant having lost so much fluid is extremely thirsty and readily sucks the fluid down. By the time that diarrhœa has set in vomiting has practically ceased, so that the fluid is retained and is rapidly absorbed into the wasted tissues. These at the end of twenty-four hours are again filled out and the extreme restlessness has gone, being caused entirely by the extreme thirst. For the collapse give oxygen freely in the manner already described, and wrap the child in a hot blanket, and maintain heat with two or more hot bottles outside this. Brandy in five-drop doses should be given every three or four hours, and strychnine—one minim of the liquor strychninæ hydrochlor. —should be given at intervals of six hours.

By these means the urgent symptoms of collapse and poisoning will be found to have considerably lessened at the end of twenty-four hours. The infant is a better colour, its tissues are filled with fluid, and it is comfortably sleeping, and no longer restless. The next question is what food to give. It is most necessary to avoid giving milk too soon or too freely. For another twelve hours it is wise to give nothing but albumen water, then introduce a weak milk mixture alternately with the albumen water feeds, such mixture being composed of two parts fat whey, one part raw milk, and three parts sugar or lactose water not more than 3 oz. at a time. Feeds should be continued in this manner for one or two days, when the infant will probably be lively, alert, and with an appetite for food. The same milk mixture should be given, but the amount can be increased to 4 or 5 oz. at a feed at intervals of two hours, and the albumen water* can be omitted. *Pari passu* with the improvement in the child the feeds can be gradually strengthened, so that in a week or ten days it is taking a feed more or less according to the requirements of its age. Only it must be remembered that relapses are frequent; any return of the toxæmia symptoms must be speedily appreciated, and the food must be lessened in its amount and strength. If at any time there be a return of pallor, vomiting and diarrhœa, then active treatment is again urgently needed. Give at once castor oil and wash out the bowel, and repeat the treatment on the lines already laid down.

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* See Appendix II, p. 201.

To increase the effect of the raw milk, cultures of the *Streptococcus acidi lactici* should be added to six or eight of the milk feeds daily. These cultures inhibit the growth of the putrefactive organisms in the bowel, and thus tend to restore the normal acidity of its contents.

In those extremely grave cases where the infant is in a comatose condition before treatment is begun, it is possible that no fluid will be taken by the mouth. It is absolutely imperative that fluid should be introduced into the tissues, and the choice of means lies between injecting it under the skin, into the general circulation, or into the rectum. First, I should choose the last route, for it can be done in a few minutes; the instruments are no more than those used for the irrigation of the bowel, and there is no danger of increasing the shock from which the infant is already suffering. Three or four ounces of salt solution at a temperature of 106° F. should be allowed to run slowly into the bowel, the buttocks being raised as high as possible by tilting the cot in which the infant is lying. This can be repeated at intervals of four or six hours. With the saline, of course, brandy can be introduced at the same time. The strychnine can be introduced under the skin, and oxygen should be given continuously for at least half an hour. By this time the child should have rallied sufficiently to suck some fluid. If, however, there is no rallying power saline should be introduced under the skin, taking the loose tissues in the axilla or armpit, as the most suitable site for this. If the apparatus is at hand, the most suitable for this purpose is a thermos flask fitted to a rubber tubing, which ends in two rather large hollow needles. One needle should be plunged into the loose skin of each axilla, and the fluid allowed to flow in by raising the flask about 2 ft. above the infant. The temperature of the fluid in the flask should be 110° F. to allow for the cooling in the length of tubing.

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* See Appendix II, p. 201.

If no such apparatus is at hand, an ordinary syringe fitted to a hollow needle can be used, the fluid at a temperature of 104° F. being forced into the tissues —3 or 4 oz. into each axilla.

I prefer, however, to use neither of these methods before a trial of injection into the rectum. However ill the infant, it seldom fails to respond to the first rectal injection; having rallied, it begins to suck saline by the mouth, and it is then unnecessary to introduce saline under the skin.

It frequently happens that when the acute symptoms have subsided the infant does not get on. Its colour is pale, it only takes nourishment moderately well, its motions are not quite normal and are offensive. There is also an irregular temperature varying between 99° F. in the morning to 100° or 101° F. in the evening. There may even be periods when the temperature is alarmingly high—104° to 105° F. These cases apparently are unable to get rid of the poisons in their system, in spite of the treatment outlined above. Apparently poisonous organisms are still able to exist in the bowel, and until these are removed the infant will not regain its health. That such is the case an examination of the abdomen will prove. This will be found to be distended and drummy by reason of the gas formed by the organisms in the bowel. Consequently we have to wash them out, and the most satisfactory treatment is frequent small doses of sulphate of soda. 3 or 4 gr. of this salt in water should be given every three hours before each feed. It will, of course, be necessary to select the infant's feed with the same care as in the acute stage, and especially to avoid overloading. The sulphate of soda should be given until the temperature has remained normal for quite a week; it should be then gradually omitted.

There are other types of toxæmia or poisoning; not, indeed, from organisms, but from the actual elements of the food-stuffs.

Of these two present unequivocal pictures, and are:—

(*a*) Fat toxæmia due to impaired digestion of fat.

(*b*) Acidosis or acidæmia due to imperfect digestion of starch.

(*a*) Fat toxæmia gives a special and characteristic picture. The infant is apparently very contented and good, but does not get on; its weight is stationary or varies—up one day and down the next. The infant's colour is most characteristic; the skin loses its healthy pink tint, takes on a very definite primrose yellow colour, and looks thick and waxy, suggesting a tallow candle.

As the toxæmia advances the state of placid contentment gives place to drowsiness; there is vomiting, refusal of food, and the stools become stodgy and sour-smelling, of a paler colour than normal. When this condition is reached the infant is gravely ill; it is being poisoned by fat, and it is extremely difficult to turn out the excess of fat stored up in the cells and to get them back into working order. This type of infant is found most frequently to have been fed either upon a strong milk mixture to which cream or Virol has been added, or upon Glaxo.

These are the two conditions under which I have usually met cases of fat toxæmia, and I have in consequence been impressed with the lack of observation on the part of the nurse or mother. The infant has not been getting on, it has refused food or taken it capriciously, and yet the feeds have been strengthened instead of weakened, and in addition cream has been added. The body cells take up excess of fat and store it, we know, but by feeding in the manner described the storage capacity of the cells has been overtaxed, and the whole system has been flooded with the excess, which acts as a poison.

The treatment here is, as before, to remove the cause. Stop giving fat for a time in any form. Sweep out the contents of the intestine by means of castor oil and a colon irrigation, and give nothing but saline solution for twenty-four to forty-eight hours. Then alternately with the saline for two days give feeds of Nestlé's milk, "Ideal" brand. The fat content of this milk is small, and it is, therefore, a useful rest feed in this condition. Being unsweetened, it requires sugar to be added to it, and should be given in strength of one teaspoonful of the "Ideal" in seven teaspoonfuls of sugar water. By the end of this time—three days—the infant should have lost its drowsiness and show some return of appetite. A milk mixture prepared from separated milk should then be given, such as fat whey, milk, sugar water, of each 1 oz. This feed contains only a very little fat, and after two or three days the infant's appetite will probably be insistent, it will clamour for food.

The feeds may now be prepared from ordinary fresh milk, only it is essential to keep the fat content low; to do this it is of advantage to have some separated milk as well as the whole milk from which to prepare the feeds. Thus our mixture of equal parts of fat whey, milk, and water will obviously contain $\frac{2}{3} \times 4{\cdot}00 = 2{\cdot}66$ per cent. of fat if fat whey and milk are both taken from whole milk, whereas by making the fat whey from separated milk we have only $\frac{1}{3} \times 4{\cdot}00$ fat in our mixture, or 1·33 per cent.

This, of course, implies our fresh milk showing a cream percentage of 4 per cent. It may be a little less than this, and this is a help rather than a hindrance. The point is to get the excess of stored-up fat out of the system and keep the infant underfed with this ingredient. It will then get on, but will readily show by loss of appetite, drowsiness, and stodgy stools if the fat content in its feeds is becoming too high.

Medicinally, I know of only one drug of any value—namely, sulphate of soda. This, given in strength of 2 or 3 gr. at intervals of two or three hours, has a surprising effect in clearing the infant's system.

(*b*) Acidosis or acidæmia is a condition of toxæmia due to the presence of acetone in the blood. This is due to the digestion of starchy food being imperfect, and consequently it is only seen in infants during their second or later years, when much starch is consumed.

The special feature of this ailment is vomiting at infrequent intervals without apparent cause. The vomiting may become intense, lasting for twenty-four or forty-eight hours, and then the child rapidly returns to normal. It is always preceded by irritability, refusal of food, especially the starchy elements as potato or bread, and there is always present the characteristic odour of acetone in the breath and in the urine. It is a peculiar smell, a mixture of sweet and sour, and most easily detected in the breath.

Its presence in the urine can be demonstrated by the addition of some tinct. ferri perchlor., when the colour of the urine changes to deep sherry red.

Whenever these signs are observed in the child they presage a storm of vomiting as I have described.

The treatment is to give a dose of castor oil, one or two teaspoonfuls, and nothing by the mouth in the shape of food, but only albumen water for twenty-four hours. In addition, to alter the acid state of the blood, bicarbonate of soda in large doses should be given. Half an eggspoonful, or 20 gr., should be given mixed into a paste with a little water at intervals of three hours during the first twenty-four hours. After this about four doses daily should be given for three days, and this should be then reduced to two doses daily for one week. The food after the first twenty-four hours should be only milk feeds, diluted according to the age of the child—a teacupful of milk 3 parts, sugar water 2 parts; or perhaps a little stronger, as milk 2 parts, sugar water 1 part.

On the third or fourth day the child will be hungry, and a little starchy food should be added. A slice of bread and butter with the morning and evening meals, and a milk pudding, either of tapioca or custard powder, at midday.

Glucose is an excellent starchy food to begin with in the case of infants under eighteen months of age. By beginning with this and going on to the heavier forms of starch we are able to gradually re-educate the infant's powers of digesting starch.

CHAPTER III

(*a*) RICKETS

(*b*) SCORBUTUS

IN our study of the diseases of infants caused by faulty feeding we have seen that the outstanding feature has been wasting or not getting on.

We now have for our consideration rickets, a disease which owes its origin to faulty feeding, but has for its most prominent symptom overgrowth. The tissues thus formed are, however, not healthy tissues; the increase of weight is excessive and well above the normal, but though plump the infant is not strong; the muscular power is feeble, the bones are soft and readily bend, and its power of resisting infection and of combating disease is low.

Rickets is indeed a serious malady; for, although not of itself a fatal disease, yet the mortality of rickety infants affected with colds, bronchitis, measles, &c., is extremely high, owing to the readiness with which bronchopneumonia supervenes in such infants as a complication of these illnesses. In addition, remote effects of rickets are seen in adult life: the softening of bones producing deformities of the chest, spine and pelvis. As a result we meet with narrow- and pigeon-chested individuals, with poor chest expansion, and consequent tendency to tuberculosis; others, again, who show a badly-bowed back—kyphosis—owing to softening and flattening of the bodies of the vertebræ; and lastly, pelvic deformities, which in women form serious obstacles to the normal passage of the infant in childbirth.

Rickets occurs mainly in urban or thickly-populated areas, where the overcrowding is responsible for lack of sunshine and fresh air. It is, however, seen in country districts in infants that have been improperly fed.

It is practically never found in breast-fed babies, unless breast-feeding is continued after the normal term—that is, nine months—even though the mothers and infants are living under the worst conditions of slum life. It is therefore not caused alone by absence of sunshine and fresh air, but is as well due to the absence of one essential item in the infant's dietary—namely, fat. In addition, an infant fed persistently upon boiled or sterilized milk shows some rickety manifestations, though not in such exaggerated form as in those fed entirely upon proprietary foods. In these the fat content is low, the carbohydrate element being represented almost entirely by sugar, so that in such a food we have all the requirements for producing the condition known as rickets, a cooked food with little or no fat. Even though fat be added to a proprietary food by means of milk, yet rickets will develop by reason of the cooking of this.

Now obvious rickety manifestations do not appear as an early sign of this faulty feeding. On the contrary, an infant so fed appears to thrive, gains flesh rapidly, and beyond flatulent dyspepsia and pale, flabby appearance, seems to be perfectly well.

It is only about the tenth month of the infant's life that well-marked symptoms arise, although they may not develop until later—towards the end of the second or even in the third year.

The average age, however, for the appearance of the characteristic signs of rickets is from the tenth to the fourteenth month of the infant's life.

It is in the bony skeleton that these signs are found. Thus the head is large and square, with prominent forehead, and a widely-open anterior fontanelle. The long bones show swelling of their epiphyseal ends, and, in the case of children who are beginning to walk or crawl, bowing of the arms and legs. The ribs show swellings at their junction with the sternal cartilages, forming down each side of the chest wall a succession of nodules, resembling in their arrangement, one above the other, a string of beads, hence the term "the rickety rosary."

These are the obvious signs of rickets, and we will pause to discuss their origin.

It will be remembered that the long bones are laid down in cartilage and have three growing centres, one for the shaft and one at each end known as the epiphysis; the whole is surrounded by a membrane—the periosteum—which is lined by osteoblasts or bone-forming cells. The normal process of growth of these cells, cartilage and bone-forming, is like all cells by cleavage, the latter pushing out processes between the cartilage cells, and depositing lime in their interior so that regular trabeculæ of bone are formed, containing in their meshes blood and cartilage cells. The cartilage cells eventually disappear, and leave the loose bone of honeycomb appearance known as cancellous tissue. Around this layer upon layer of hard compact bone is deposited by the growth and calcification of the osteoblasts lining the periosteum. As the bone grows in thickness by these successive layers, so the centre of the shaft becomes hollowed out by absorption; thus we have formed what is known as the Haversian system—a central canal, around this cancellous tissue, and around this a solid layer of compact bone. In rickets this growing tissue has the appearance of inflammation; the blood supply is increased, and the osteoblasts show hyperplasia, are over-active; their growth and powers of absorption are excessive, but in spite of this there is a deficiency of lime salts deposited in them; in other words, ossification is incomplete.

As a consequence we find the Haversian system consisting of a central canal larger than normal; a large area of cancellous tissue formed for the most part by imperfectly ossified cells, and a thin layer of compact bone which also contains unossified islets of cartilage cells. In addition, underlying the periosteum many unossified cells and blood cells are formed; the periosteum strips from the shaft readily, and spicules of bone are seen attached to its inner surface. We thus see how readily these badly-formed long bones can bend, are unable to support weight or muscular pull; hence we get in rickets exaggeration of the normal curves.

At the epiphysis there is the growing edge of cartilage between the shaft and terminal end of the bone, which, under normal conditions, continues to grow in regular order; a narrow advancing band of cartilage cells, behind this a band of cartilage cells in process of ossification, and behind this a layer of completely ossified cells forming cancellous tissue. The length of the shaft is determined by the life of this growing band of cartilage. As soon as it is used up the epiphysis becomes united to the shaft, which has thus reached its appointed length.

Here also in rickets there is evidence of active hyperplasia resembling inflammation. The cartilage cells are in greater amount than normal, the growing band of cells is thickened; so, too, is the layer behind of partly ossified cells. But in this and the succeeding layer there is deficient calcium deposited. Consequently there is an irregular arrangement of cartilage cells incompletely ossified, and, in addition, swelling of the whole epiphysis. In this way we see why the epiphyseal end of the long bones, as, for example, the radius or tibia, is swollen and may be tender. The same is seen at the growing end of the rib, the junction of each rib with its sternal cartilage, forming by these swellings the well-known rickety rosary down the chest wall.

In addition to this nodular swelling at the growing end of the rib, there is the yielding of the shaft of the bone to atmospheric pressure in consequence of the rickety softening. As a result the chest loses its rotundity and becomes flattened at each side, assuming a flask shape; the sternum pushed rather forward, the sides pressed in with a concavity outwards in place of the normal convexity.

We should also note that the over-activity of the cartilage cells in their growing period causes them to be used up too soon. Hence the epiphysis is united early with the shaft, and consequently the individual presents a stunted growth at maturity.

The bones of the skull also show thickening and hyperplasia of their centres of ossification; as a result bosses are formed. But as these bones are not laid down in cartilage but in membrane, and depend for their development upon the radiating growth of their centres of ossification, it is clear that their final conversion into bone is delayed, the edges round the centres remaining still as membrane in consequence of the faulty growth of each centre of ossification. Hence we see why the closure of the sutures is delayed, and why the anterior fontanelle remains so widely open when normally it should be closed. For, owing to the delay in the growth of the bones which enter into its formation, the two frontal and the two parietal bones, this large gap between their edges known as the fontanelle must of necessity remain a gap until the growth is completed.

Now stress has been laid upon the word obvious. It is true that these changes in the bony skeleton form a considerable part in the picture of rickets, and they are so obvious that they cannot be mistaken. But they are not the only evidence of a rickety condition; in fact, they are really the late manifestations, the results, that is, of the disease when well established. It is important to grasp the fact that the true cause of rickets is of the nature of a poison circulating in the blood, and that all the tissues of the body are affected thereby. The muscles, nervous system, digestive system, the blood itself are all altered; in other words, the balance of nutrition is not true. If we are observant, we shall notice less obvious signs of rickets which precede the obvious ones we have already discussed, and by so doing we shall be able to start our treatment at an earlier period of the illness and prevent the gross changes in the skeleton. This, of course, is of vital importance.

What, then, are these early signs?

First, restlessness at night. The child is constantly tossing in its sleep, and is never found with its bedclothes over it. It appears to be quite intolerant of the weight of the clothes. In addition, there is marked sweating of the head. This is a most characteristic early sign. It is extreme, causing the pillow to be wet through and, curiously, only affects the head, the body and extremities being quite cold at the same time. The colour of the infant during the day is suggestive. In place of the healthy pink tint to the skin there is extreme pallor, white, with a suspicion of blue in its depth, and as well pearly white conjunctivæ of the eyes. The child is anæmic, but this blood change is rather a later result of long-continued rickets than one of the early signs. The peculiar dirty white pallor, so suggestive of a toxæmia, is the colour to recognize as an early sign of rickets.

Next in order, the flabbiness of the muscles will be noticed. The infant cannot sit up; in fact, there is a noticeable loss of tone of the whole body. The legs and arms feel soft, although they are extremely plump; there is no firm resistance to the hand such as one experiences upon grasping a normal infant's limbs. Dentition is also affected. The teeth are delayed, and in place of the normal eruption of the incisors at the seventh or eighth month teeth may be entirely absent at one year or later, and then begin to make their appearance in irregular order; it may be one canine or even a molar showing first before any of the incisors.

The stomach and intestines also show signs of dyspepsia. There is much flatulence associated with constipation, and the abdomen is enormously distended. This is due at first to gas formation from the faulty feeding, but as well in the later stages it is augmented by the descent of the liver and spleen into the abdominal cavity. It will be remembered that normally these organs are covered in by the lower ribs, and do not occupy any part of the abdomen; but owing to the diminished chest capacity, consequent upon the falling in of the ribs, there is no room for liver and spleen in the thorax; both organs, therefore, are felt below the thoracic border, and help to cause the remarkable swelling of the abdomen so characteristic of rickets.

That the nervous system is affected is shown by the restlessness of the infant as above referred to. But, as well, convulsions are common in rickets, which suggest irritation of the lining membranes of brain and spinal cord by some poison circulating in the blood. Another form of irritation of like nature is spasm of the glottis, which produces a harsh, croupy note on inspiration to which the name laryngismus stridulus is given. The infant is in great distress from deficient supply of air so long as the spasm lasts; but when apparently *in extremis* the spasm suddenly yields, and the infant's condition is at once as good as before. It is extremely rare for this affection to be the cause of death, probably because the most powerful stimulus to the respiratory centre in the brain is de-oxygenated blood. When, then, the infant is almost black and looks to be in its death struggle, the respiratory centre is so stimulated that the spasm of the glottis is overcome and a normal airway is established. Yet the attack is alarming and calls for prompt treatment.

The lungs very commonly show some bronchitis, and there is a very great tendency for this condition to extend to bronchopneumonia with a fatal result.

Treatment.—Treatment naturally falls under two headings:—

(*a*) The causes of the rickety condition—namely, the faulty feeding and unhealthy environment—and

(*b*) The symptoms.

With regard to the former, plenty of fresh air and sunlight is to be obtained, although it should be remembered that no infant can stand exposure to the direct rays of the summer sun. Frequently one sees an infant placed in the full glare of a hot sun; no one, least of all a delicate infant, can stand continuous exposure to the sun's rays in full summer without suffering intensely therefrom. It is therefore necessary to observe caution in the matter of sunlight, and never to omit shading an infant from the sun.

As to the feeding, fresh uncooked cow's milk must replace the cooked milk or patent food. The carbohydrate element hitherto supplied in the form of sugar must be replaced by fat; and starchy food, such as milk puddings or bread, should for a time be withheld. We have to remember the condition of dyspepsia, the distended and overworked bowel, associated with constipation. It is therefore necessary to unload and rest the digestive organs so that they may be restored to normal working; until this is accomplished all the treatment is valueless.

It should also be remembered that the infant is over its normal weight, due to deposit of fat in its tissues. One can therefore be satisfied that a low diet will not affect the infant's comfort. It will not evince hunger, as there is so much reserve material to draw upon; and the most satisfactory sign of return to health of a rickety infant at the commencement of treatment is a fall in its weight. If this initial fall does not occur, one should look upon one's dietary as being still too large for the infant's needs, and should reduce it accordingly. For the unhealthy tissues must be rendered firm and healthy by removal of excess, and will later be replaced by sound tissue through the regenerated digestive system.

As a beginning, then, give an aperient, such as one or even two teaspoonfuls of castor oil, followed by six hours' starvation diet—that is, sugar water or saline, 4 oz. every two hours; as well, irrigate the colon daily for a few days, then at longer and longer intervals.

Commence feeding at the end of six hours with a weak milk mixture: Milk, 2 oz.; sugar water, 3 oz.; a 5-oz. feed, given at intervals of two and a half hours. Keep the infant on this for at least three days, and give no other food. As soon as hunger is manifested the feeds can be strengthened by degrees every third day, changing to equal parts of milk and sugar water; then three parts milk, two parts sugar water; then two parts milk, one part sugar water, and so on, at the same time prolonging the interval between the feeds to three hours, and increasing the amount to 6 oz. As well, at the end of a week some starchy food should be incorporated with the feeds. Half a Robb's biscuit morning and evening, and at midday a small amount of floury potato should be given with the milk feeds. In addition, the juice of an orange should be given daily. Infants enjoy it immensely, and it has a surprising effect in lessening the sweating and restlessness. It should be prepared by cutting the orange into quarters, expressing the juice, which should then be sweetened and strained. As the juice will not keep it is necessary to make a fresh supply each day. If oranges are unobtainable, lemons are equally as good or the juice of English hothouse grapes.

By the end of a week or ten days the infant should be looking a good colour, and already showing increase of muscular power by sitting up in its cot. The fall in weight, at first rapid, will have slowed down, and it maybe have taken a turn in the opposite direction, the weight chart showing a steady ascent. The improvement will now be advanced still further by the addition of meat extracts or gravy to the diet: As will be remembered, the value of these food-stuffs is not so much in the number of calories they contain as in their action on cell activity. They intensify the interchange in the cells, and so are given to increase their working capacity. As previously stated, one tablespoonful of a mixture of one teaspoonful of Bovril in 4 oz. of hot water should be given in two or three milk feeds a day. The appetite, colour, and vigour of the child will all improve, and in from two to three weeks' time a diet suitable to a normal child can be readily taken.

The daily airing, both morning and afternoon, should, of course, be given concurrently with the improvement in the infant. Only, as rickety infants are prone to take cold easily and to show signs of bronchitis, care must be taken that they are warmly clad, and discrimination shown in the matter of the weather conditions.

While the infants are flabby and listless, they of necessity have to lie in their cots for the greater part of the twenty-four hours. But much good can be derived from the gentle massage of the muscles of the arms and legs. In addition, any bowing of the limbs can be straightened out by steady pressure opposed to whatever faulty curve the limb shows.

Attention to these details regularly each day will be rewarded by straight limbs and do away with the need for splints, provided the infant is not allowed to crawl or stand on its feet whilst the bones are still soft. After about four to six weeks' treatment the bones should be straight and hard, and little by little crawling and walking may be resumed.

Of drugs, none are of any use as a cure of rickets. The only cure is correct feeding, accompanied by good hygienic conditions, and it is fallacious to suppose that there is any short cut to health without attending to these two principles.

But several prominent symptoms can be relieved by means of drugs, notably the sweating and the restlessness. For these small doses of the tincture of belladonna with bromide of sodium are excellent, and will speedily effect an amelioration of the symptoms. To aid the return of the digestive organs to normal, there is nothing better than the addition of the lactic acid organisms to the milk feeds.

Cultures of these are continuously grown at The Infants' Hospital, and systematically used in the treatment of infants in the wards and attending out-patients. It is remarkable how their use speedily improves the infant's colour. But it may be found in long-standing cases that the colour does not become good. There is a definite anæmia or poorness of the blood. The iron content in the red cells is low, and this can be improved by treatment with iron in an easily assimilated form. The most useful preparation is the dialysed iron in ten or fifteen-drop doses twice daily.

Beyond these remedies I have found none of any use; and have seen much harm from some of the belauded remedies such as cod-liver oil and its derivatives. If the state of the digestive organs is borne in mind, it is easy to see that a heavy oily fluid cannot but hamper these in their action still further.

The natural fat of milk is all-sufficient, and this should be given diluted with water in the proportion of four parts cow's milk and one part water. Whole milk is occasionally well borne by an infant of fifteen months or over, but as a rule a diluted milk is preferable.

SCORBUTUS OR SCURVY.

This is another disease of infants resulting from feeding persistently with patent foods or sterilized milk. It is occasionally seen in breast-fed babies, but this is rare. Unlike rickets, it is not intimately associated with absence of fresh air and sunshine; but is rather a disease of the well-to-do, where the hygienic conditions are beyond reproach. Although it may be seen in association with rickets, yet it is not to be looked upon as a part of this disease. It is a disease standing by itself, and its principal feature is a tendency to hæmorrhages. These hæmorrhages occur beneath the skin, beneath the periosteum, beneath the mucous membrane of the gums. Hæmorrhages also may occur into the joints, into internal organs, stomach, intestine, bladder.

The age incidence is usually between six and fifteen months. The onset of the disease is quite sudden. An infant which has been apparently perfectly well will suddenly give evidence of excessive pain in one or other leg; for the most common symptom is hæmorrhage beneath the periosteum of the lower end of the thigh or the lower end of the tibia.

Swelling of the part is noticed, which may or may not be of a dusky colour. It is excessively tender to the touch or upon movement. In fact, so careful is the infant not to move the affected limb that often the whole leg appears to be paralysed. A mistake in diagnosis should not be made, as other signs will probably be present, such as petechial spots of hæmorrhage appearing like bruises beneath the skin and spongy gums. These are purplish-red in colour, appear fleshy and overhang the teeth, or where teeth are not yet erupted are swollen, and in appearance like maroon-coloured bladders. In addition, there may be vomiting of blood, bright-coloured or brown, similar in appearance to coffee-grounds. The colour of the dejecta may be black, showing the presence of altered blood in the stools, or there may even be blood in the urine.

If untreated the child becomes gravely ill, gets worn out from want of sleep, and dies from exhaustion.

The treatment is simple and most satisfactory. Fresh milk modified to the infant's requirements must be given, and as well the juice of raw fruit, such as orange, lemon, or grape. In a surprisingly short space of time the urgent symptoms disappear, and the child gets well without any trace of the illness being left behind.

Bleeding into the epiphysis may cause separation of this from the shaft. This will require to be treated by means of splints, but the prognosis for this is quite good under a rigid and correct dietary.

CHAPTER IV

ACCIDENTAL COMPLICATIONS

(*a*) *Intussusception*
(*b*) *Appendicitis*
(*c*) *Strangulated Hernia*

WE have now come to the end of our studies of those diseases of infants directly resulting from improper feeding. As these comprise at least 90 per cent. of the causes of death in the first year of infant life, the description, origin and treatment have been detailed at length. Furnished with a sure knowledge of the development of the infant's digestive apparatus, its working and the normal limits of its powers, we should avoid causing any of these illnesses by a proper use of this knowledge, and further, should be able instantly to recognize and treat any of the symptoms arising in our infant suggesting the onset of any such illnesses.

But what I may term accidental complications do arise in an apparently healthy infant—that is, being correctly fed—associated with grave symptoms in the digestive track.

Such are intussusception, appendicitis, and strangulated hernia.

By intussusception is meant the invagination of a portion of the intestine into itself, and it is apparently caused by irregular peristalsis resulting from undigested food. Normally the peristaltic action of the small intestine proceeds in rhythmic waves from the pylorus to the ileo-cæcal valve; each wave of contraction occupies a small segment of the bowel and travels down the whole length, followed by a wave of expansion in the same direction. This again is succeeded by another wave of contraction, and so on, in regular rhythm, ever working to effect the passage onwards of the contents of the bowel. If these contents are irritating—for example, are composed of undigested masses of unsuitable food—the peristalsis is hurried, the bowel works more energetically until its muscular power is unequal to the effort; it becomes paralysed from overwork. This paralysis may occupy only one segment of the bowel; above this the peristaltic action still goes on vigorously, and eventually drives the wall of the intestine into the paralysed portion. Thus it is invaginated into itself, forming what is known as an intussusception. The process may perhaps cease, and the power of peristalsis return to the lower enveloping portion of the bowel. But of this we have no evidence. When the intussusception is formed the tendency is for the invaginated portion to act as a foreign body. Peristalsis above this is increased to force it along the bowel, and more and more bowel is invaginated.

The result is complete occlusion of the bowel, death of the invaginated portion of bowel owing to the strangulation of its blood supply, and acute inflammation of the peritoneum around this—peritonitis.

Any portion of the small intestine may be the entering portion of the intussusception. Perhaps the most common site is at the ileo-cæcal valve, the valve forming the advancing part of the invaginated portion. This has been known to travel the whole length of the colon, and has been felt by the examining finger in the rectum. The higher in the intestine is the intussusception the more urgent is the vomiting; the lower down it occurs the more intense is the straining to stool and the passage of blood-stained mucus.

The symptoms are extremely urgent; they are vomiting persistently, pain evidenced by shrieking and drawing up of the legs, severe collapse, and, what is most characteristic, frequent straining to pass a motion, the result being the passage of a little blood-stained mucus. As the infant becomes more and more collapsed it lies flaccid with drawn face and anxious expression, pulse is small, thread-like, and very rapid. The lips and mouth are dry; the abdomen is tense and tender to the touch. By carefully examining with the flat of the hand laid upon the abdomen one can feel the presence of a lump, usually described as sausage-shaped, lying to the right of the middle line, a little below the centre. This is the intussusception, and if felt there should be no delay in having the infant operated on. By an early opening of the abdomen the intussusception can be unravelled, and the bowel will resume its normal working.

For a complete account of this affection the standard text-books on surgery and medicine should be consulted. The point I wish to draw attention to is the possibility of this disease occurring in an infant as young as six months, and it should be thought of in association with grave and urgent abdominal symptoms. It is probably most frequently met with in the second or third year of life, but it is by no means uncommon in the later months of the first year of infant life.

Appendicitis, inflammation of the appendix, is a much rarer affection than intussusception in infants, although it has been met with in an infant three months old. The situation of the vermiform appendix is along the side of the cæcum, the first portion, that is, of the large intestine. Consequently any inflammatory condition of this organ gives rise to local signs in the region of the cæcum, which is in the right iliac fossa—that is, low in the abdomen above the right hip-joint; and as well general symptoms of fever and pulse-rate and temperature raised, together with symptoms of disturbance of digestion, vomiting, pain and diarrhœa. It is important that the signs of peritonitis should be clearly recognized. The principal one is rigidity of the abdominal walls, and this we can readily understand if we remember that one of the uses of these walls is to protect the abdominal contents. If these latter are inflamed and tender the muscles of the abdominal wall become tense, are in a state of contraction, on guard to prevent undue pressure from without upon this inflamed organ. Consequently the abdominal wall is rigid, does not move on respiration, and feels tense to the examining hand.

We should, then, always first of all look carefully at an abdomen to see if there is the regular rise and fall due to the descent and ascent of the diaphragm. If this is absent we should suspect peritonitis, and be extremely careful how we handle that abdomen in our examination. Meteorism or paralytic distension of the intestine gives the abdomen a distended appearance, and upon percussion a high-pitched note is obtained. Palpating such an abdomen gently with a warm hand is decidedly comforting to an infant when this distension is not associated with inflammation; but, on the other hand, if there be peritonitis, then the inflamed area is exquisitely painful; the infant is intolerant of any pressure.

In appendicitis there is a localized peritonitis, and consequently we have signs of this in the right iliac fossa—namely, rigidity and some swelling, both apparent to the eye; tenderness on palpation, and also upon moving the right leg. For it must be remembered that the large muscles which flex the thigh lie at the back of the abdomen, and adjacent to the inflamed area; consequently movements of these muscles occasion pain, and hence are avoided by the infant. Owing to this immobility of the thigh, the attention of the observer may be drawn to the leg and not to the real site of the trouble, the appendix region, a totally incorrect diagnosis of paralysis being the result.

The treatment of this affection is essentially surgical, for in infants and children resolution of the inflammation is so rare as to exclude it from the possible termination of appendicitis. The usual sequence of events is rapid formation of abscess, which, of course, should be opened as soon as possible. For if there be delay the abscess, which at first is strictly localized by an inflammatory barrier set up by Nature, will burst into the general peritoneal cavity, causing intense symptoms of poisoning and so death.

It is therefore necessary to clearly recognize the signs of peritonitis in order that no time may be lost in obtaining suitable surgical treatment. On this account I do not advise any medical treatment at all. The administration of an aperient, such as castor oil even, is excessively dangerous.

Another affection of the abdomen is strangulated hernia. A hernia or rupture is the term applied to a loop of bowel which is extruded through the layers of the abdominal wall, presenting to the eye a lump or swelling. Normally there are weak spots in the abdominal walls due to delay in their development; such are the umbilicus or navel, which in the unborn infant is occupied by the cord of vessels communicating with the mother by means of the placenta; and the inguinal canal on either side of the pubic bone, which is an opening between the muscular layers of the abdominal wall for the descent of the testicles into the scrotum in their development from the kidney region at the back of the abdomen.

This development takes place at about the sixth month of fœtal life, and at birth, or soon after, the testicles should have travelled down into the scrotum. In infants who are congenitally deficient these weak spots are especially defective, and we consequently find ruptures much more common in undersized premature infants. The development of a rupture is as follows:—

The peritoneal lining of the abdominal wall is bulged through the weak spot by intra-abdominal pressure. As this bulging proceeds a loop of intestine follows. Any increase of pressure increases the bulging of the peritoneum, so that a larger and larger cavity or sack is formed into which more and more bowel is forced. The intra-abdominal pressure is dependent mainly on gas formation in the intestines, but also on violent coughing or straining to pass urine or fæces.

It is therefore exactly in these delicate infants with imperfect digestion that all the conditions essential for the formation of a rupture are present, weak and imperfect abdominal walls, and gas formation producing increase of intra-abdominal pressure.

In the majority of ruptures the opening in the abdominal wall is so large that the bowel is not constricted thereby; it can enter the sac and return to the abdomen freely. But an extra strain from coughing or crying may thrust so large a loop of bowel through the opening that it is unable to return into the abdomen. Strangulation of the blood-vessels follows, and as a result first of all œdema, then inflammation of the bowel appear, so that a condition of local peritonitis is set up. By the consequent paralysis of the bowel there is acute obstruction to its peristaltic wave and symptoms as described in intussusception, pain, vomiting, collapse, and toxæmia are manifest. Locally the swelling will be found to have lost its elastic feel and its resonance on percussion, and instead it is hard and non-elastic, dull on percussion, and of a darkened colour. Pain on handling it will at first be elicited, but as the inflammatory process progresses gangrene of the intestine occurs, or local death, and sensation is lost. This absence of pain is an important point to remember. It increases the urgency of treatment. In any case of rupture, then, when acute abdominal symptoms as vomiting and pain present themselves, it is essential to carefully examine the rupture to assure ourselves that strangulation has not occurred. If the local signs as above described are present, then delay may be fatal; it is imperative that surgical treatment be given at the earliest moment. Here again any medical treatment should on no account be attempted; it can only end in the death of the infant. The proper surgical treatment will be found described in the surgical text-books.

PART VI

HINTS UPON THE CARE AND MANAGEMENT OF INFANTS IN DISEASE

HITHERTO our attention has been concentrated upon the feeding of the infant and upon the ailments caused by bad feeding. We still require to know what to do in other than intestinal disorders, and for this purpose I select pulmonary affections as our final study.

In these I include not only diseases of the lungs, but also those of the air-passages—that is, of the nose, throat, larynx, bronchi, lung tissue and pleura.

Such are ordinary colds, tonsillitis, laryngitis, bronchitis, broncho-pneumonia, lobar pneumonia, pleurisy, empyema and pulmonary tuberculosis.

Taking the nose and throat first, everyone is familiar with the common cold, a catarrhal affection of the upper air-passages associated with some feverishness and feeling of malaise, accompanied by a watery discharge from the nose. There is also some soreness of the throat and possibly huskiness of the voice, showing that the pharynx is affected, and also the larynx.

Healthy infants, during their first year, are extraordinarily immune to these catarrhal affections, but after this term they readily fall victims to them. It would seem that a natural immunity is handed down by the mother to her offspring, and that this immunity is used up by the end of the first year.

These catarrhal affections are perfectly simple in themselves and readily yield to treatment. But, although simple, they should not on this account be ignored, because from a simple cold grave illness may develop. Consider the relationship of the various structures composing the air-passages. At the top of the pharynx are the two Eustachian tubes; along these the catarrhal affection may spread to the internal ear; as a result a chronic inflammation may be started leading to the destruction of the hearing apparatus and the drum, with a constant discharge through the external ear. There are other complications arising from the ear, still more serious, such as an abscess in the wall of the skull, leading to inflammation of the membranes surrounding the brain, or even to an abscess in the brain. These are outside the scope of our present study, but the possibility of their connection with a neglected cold must ever be borne in mind.

In the pharynx are the masses of lymphoid tissue, three in number, known as tonsils, which it will be remembered act as filters of or barriers to infective processes. In the case of a cold they become inflamed, but in a few days this inflammation should subside. It frequently happens, however, that, owing to neglect, this inflammatory process persists; the tonsils become enlarged, and contain in their substance points of septic material which from time to time light up into an acute inflammatory condition. At this stage the child is pronounced to be suffering from tonsils and adenoids, the tonsil at the back of the nose being known as the adenoid tonsil. This really means that all three tonsils are chronically enlarged, and the increase in their size causes obstruction to the normal airway through the nose. In consequence insufficient air is drawn in to satisfy the demands of the organism, and the child has perforce to breathe through the open mouth. It becomes a mouth-breather by day and night, and when asleep snores loudly. In addition, there is more or less constant discharge from the nostrils, which may, after the night's rest, become blood-stained.

As a result there is impaired development, not only of the skeleton, but also of the nervous system. The child is mentally and physically backward.

Another effect of this chronic inflammation of the tonsils is enlargement of the lymphatic glands in each side of the neck. It will be remembered that these are situated along the main blood-vessels, and drain the lymph flowing from the tonsils. Any septic material in these latter having broken through Nature's barrier will pass on into the lymphatics, and be caught up in this chain of lymphatic glands on each side of the neck. Inflammation and swelling are the result. By far the commonest cause of swellings in the neck in infants and young children is this chronic tonsillar infection. Often the swollen glands suppurate; an abscess is formed and evacuated through the skin of the neck. Thus a scar is formed which leads to the erroneous conclusion that the possessor of such a scar is tuberculous. This, of course, may be true, but it should be remembered that the vast majority of such swellings and abscesses are not caused by the tubercle bacillus, but by septic infection of the tonsils. Hence the obvious remedy is to remove the tonsils. When this is thoroughly done the glandular swellings in the neck subside.

Passing along the air-passages, the larynx at the top of the windpipe quickly becomes involved in a catarrhal affection of the nose and throat. There is pain in swallowing, and hoarseness in crying or speaking. In addition, there will be a short, sharp cough which is extremely painful. The infant dreads to cough. There may be also a spasm of the larynx which causes alarming symptoms of partial suffocation (but which yields to warmth). This is unusual in a normal healthy child, but is common in severe rickets. To this condition the term laryngismus stridulus is given on account of the hoarse or hissing noise made at each inspiration by the air entering the contracted larynx. The obstruction to the air entry is also shown by violent effort on the part of the extraordinary muscles of respiration and by the sucking in of the interspaces between the ribs. In addition there is extreme cyanosis, the colour of the child is blue, and it is extremely anxious and restless.

By extension along the trachea from the larynx the catarrhal condition reaches the bronchial tubes. Bronchitis is thus set up, giving rise to wheezy or rattling respiration, which is much quicker than normal, and to a good deal of cough. At first the cough is dry, but later, as healing goes on, it becomes loose. Phlegm, the name given to the secretion of the bronchi, is coughed up, expelled by muscular effort from the tubes. In infants and young children it is seldom expectorated, usually it is swallowed, but may be expelled in the act of vomiting. The catarrhal condition may only involve the lining membrane of the bigger bronchi and subside in the course of a few days. In this case the infant is not seriously distressed. But when the finer divisions of the bronchi are involved, then there is much distress from hurried breathing and the tight constant cough. The temperature is considerably raised above the normal, the heart's action is quickened, and the infant is seriously ill.

From this condition of acute bronchitis it is only a short step further to broncho-pneumonia. The catarrhal affection has not only involved the lining membrane of the fine divisions of the bronchi, but has extended to the walls and the interstitial tissue holding them together. Patches of inflammation of the lung tissue are thus formed, at first separate, distributed here and there throughout the lungs. Later by extension neighbouring patches coalesce, so that the whole of one lobe may eventually become one continuous mass of inflamed lung tissue. Pneumonia is the term given to inflammation of the lung, but to distinguish this particular variety which owes its origin to extension of inflammation from the bronchi, broncho-pneumonia is the term used. It is a serious condition, for each patch of inflamed lung is unable to carry on its normal function; where many patches coalesce it is obvious that a large area of the whole lung is put out of action, and in consequence the breathing is laboured and distressed.

Another point to remember is the tendency of this condition to spread; one patch clears up, but a fresh patch or crop of patches develops in other parts of the lungs, so that the illness is long drawn out. It does not terminate suddenly nor yet quickly. Consequently the infant's strength is most seriously impaired, and in those who are delicate, whose strength is already low owing to digestive disturbances, as already described, the outlook is most serious, and a fatal termination only too common.

The most characteristic symptom of broncho-pneumonia is the breathing. The infant is a bad colour, with pale, anxious expression; its breathing is quick, the nostrils are thrown widely open, and there is a peculiar grunt with each expiration. When this grunt is present there should be no doubt about the diagnosis; it is symptomatic of broncho-pneumonia widely distributed throughout the lungs, and is of grave significance.

There is nothing in the temperature chart to distinguish bronchitis from broncho-pneumonia; usually one sees the temperature raised to about 100° F. in the morning and 102° F. in the evening.

Improvement in the patient's condition is shown day by day by the gradual fall of the temperature to normal. In broncho-pneumonia, after remaining normal for some days, it again may arise, showing that a fresh patch of inflammation has developed in the lungs. Again there will be gradual recrudescence of the temperature to normal, and so on, each fresh infection being recorded by a rise in temperature higher in the evening than in the morning. In severe attacks the temperature chart shows wide difference in the morning and evening—103° or 104° F. in the evening and 99° to 100° F. in the morning. In these severe cases it must be remembered that the falling temperature does not necessarily indicate improvement in the patient's condition, but rather the reverse, for as the strength of the patient ebbs there is less and less reaction to the illness as shown by the temperature. Consequently in a falling temperature the patient's condition must be closely observed. If it shows improvement, then the lowering of the temperature is a good sign; but if, on the contrary, the patient is not so well, then a falling temperature is an extremely bad sign.

The above description of the course and symptoms of a catarrhal affection of the air-passages is sufficient to enable an untrained observer to form an opinion upon the nature of the infant's illness; the physical signs associated with the same are sufficiently described in medical text-books, and need not be recapitulated here.

Lobar pneumonia, pleurisy, and tuberculosis of the lungs, being different in their origin, will be considered later.

We now come to treatment: The point to remember is not to ignore a simple cold.

An infant is extremely tender, and, moreover, cannot record its feelings. We have therefore to see that the proper treatment is resorted to as soon as any symptoms show themselves.

For a cold warmth is essential. The child should not be taken out for its daily airing, but should remain in a warm, airy room. By keeping it in its nursery for a few days a cure will be speedily effected, and the daily airing can then be resumed. Attention to the clothing is important. In cold weather a woollen undervest should always be worn; in older children this should be in the form of combinations. Woollen gaiters should also be worn over the legs; it is a mistake to send young children out in cold weather with bare legs.

If the temperature is raised the child should remain in bed both night and day; after it has returned to normal some portion of each day may be given up to exercise in the nursery; after two or three days the child may be taken out.

In laryngitis and bronchitis or broncho-pneumonia the distressing cough and spasm of the breathing are greatly relieved by placing the child in its cot in a tent into which steam is introduced by means of a bronchitis kettle. It is better to make a tent round the cot, leaving one whole side open, than to draw the curtains of the cot round the child and pour steam into this enclosed space. Fresh air must be given to the child with the steam, and if the tent is placed too closely round the child sufficient air is not given, and there is danger of suffocation in consequence. As soon as the cough is loose the steam should be omitted, at first during the daytime only, then later during the night as well; there should always, however, be a return to the steam if the cough again becomes hard and tight.

Local applications to the skin of the throat and chest are of great value; although owing to the tenderness of the infant's skin these should not be very hot or irritating. Camphorated oil rubbed in each night, followed by an application of cotton-wool, to the throat in laryngitis, or to the chest in bronchitis, is of undoubted value. A cotton-wool jacket can readily be made of Gamgee tissue by stitching two pieces together and tying the whole over each shoulder. Quite a simple jacket is made by tacking swansdown inside the child's vest; the objection to this is that it can only be removed by pulling it over the child's head, whereas a properly made jacket should tie at the sides and over the shoulders, and can thus be taken off and re-applied without disturbing the patient.

This method of warming and stimulating the chest is greatly to be preferred to a linseed poultice. A poultice retains its heat for but a short time, and when cold may be harmful by reducing the infant's vitality. Constant application of poultices must disturb the patient's rest, and this should be avoided, as sleep is so essential to its well-being.

Diet is a most important part of treatment. Owing to the feverishness the entire organism is working badly, the balance of nutrition is upset, and the powers of digestion are less than in health. Consequently it is essential to at once reduce the feeds both in amount and quality.

If the patient is taking only a milk modification, then it is necessary to lessen the amount of fat and caseinogen in the mixture. It is well also to give the feeds in smaller bulk and at more frequent intervals. In the case of an older child solid food should be withheld, and only diluted milk feeds given so long as the temperature is raised. Appetite will reappear directly the temperature falls, and then there should be a gradual return to normal feeding. Owing to the feverishness thirst is pronounced, so that between the feeds small drinks of cold water should be given. No possible harm can result from this, although it is a curious popular belief that cold water is dangerous. In the case of older children it is sometimes necessary to bargain with the patient: no cold water unless the milk feed is taken; for refusal of feeds may be a serious matter, and therefore a compact of this nature is useful. This appears to me to be the only reason for withholding refreshing drinks of cold water from a patient.

Drugs are of value in relieving the intensity and spasm of the cough, in helping to loosen the phlegm, and in stimulating the patient.

For the first, the compound tincture of camphor, which contains a little opium, is excellent. Spasm is best relieved by tincture of belladonna, with or without bromide of sodium. All given in minute doses according to the age of the patient. Ipecacuanha wine in small repeated doses helps to loosen the phlegm; if given in large doses—say a half to one teaspoonful—it acts as an emetic, which is an excellent means of clearing the bronchial tubes. Owing to the weakening effect of vomiting I prefer to avoid this action of the drug as long as possible—that is, until it is seen that steam will not relieve the child. One dose only should be given; on no account should a second dose be administered within twelve hours of the first.

Tolu has a most soothing effect upon the irritable mucous membrane of the air-passages, and in the form of syrup of tolu should be added to any mixture for relieving cough and spasm. Frequently it is sufficient of itself to allay the symptoms, and is, therefore, a splendid auxiliary to the drugs named above.

As stimulants, brandy five to ten drops every four hours, and oxygen, as previously described, should be administered. Of drugs, ammonia and strychnine are both invaluable. Ammonia is best given in the form of sal volatile—the aromatic spirit of ammonia—three to five drops for a dose. Strychnine in the form liquor strychnin. hydrochlor., in doses of one drop every four or six hours, should be given in severe cases. It is a powerful nerve stimulant, but its effect must be watched; muscular twitchings of the patient are indicative of poisoning by the drug, and call for less frequent doses. But it is better that the twitchings should be present than that the child should die for want of stimulation.

Tuberculosis in its distribution throughout the lung is identical with and indistinguishable from broncho-pneumonia. Indeed, it frequently happens that broncho-pneumonia passes on into tuberculosis by reason of the infection of the inflamed lung with the tubercle bacillus. In infants, however, the commonest site of tuberculous infection is not the lung tissue, but the bronchial glands. It must be remembered that the tubercle bacillus is a spore-bearing organism, and that, therefore, these spores have extraordinary vitality. They can exist for an almost indefinite time in the dusty corners of a badly-cleaned room. The dust when raised is inspired by the infant, and the spores are in consequence drawn into the bronchial tubes. Being impurities, they are either coughed out or passed on by the lymphatics into Nature's filters, the bronchial glands. Here they develop into active tubercle bacilli. Nature attempts to defeat this invasion of the bacillus by throwing up a barrier of inflammation in the gland. If she wins the process stops; the inflammatory tissue is partly absorbed and partly converted into fibrous tissue; in the interior of this is a mass of dead tissue with dead bacilli, the whole forming a caseous or putty-like mass, which finally loses its watery constituents, and remains a chalky concretion. It is incapable of doing further harm.

But if Nature does not win, the tubercle bacillus grows in this nest and sends its numerous progeny into the blood-stream. By this means the tubercle is disseminated throughout the system, so that many similar nests are formed in different organs of the body. The lungs and the membranes of the brain are the two most common sites of this secondary infection, and in the lungs each nest produces a patch of inflammation in the lung tissue—in other words, there is broncho-pneumonia of tuberculous origin.

There are no distinctive signs in the appearance of the child to enable the observer to distinguish this type of broncho-pneumonia from the catarrhal or simple kind. When, however, the temperature continues above normal for a considerable time, and shows no gradual decline to normal, and, moreover, if there are wide differences between the morning and evening temperature, it is reasonable to suspect that the child has tuberculosis of the lungs. The physical signs are described in the medical text-books, which should be consulted for a fuller knowledge of this subject.

Treatment is on the same lines as already described, but it must be remembered that fresh air is even more important in a case of tuberculous than simple broncho-pneumonia. In addition, the child should be in a room by itself; this is true of all illnesses, but doubly so where tubercle is suspected or known to be present.

Finally, the nourishment must be as full as possible. It is wrong to underfeed these cases of long-drawn-out temperature.

Plenty of good food, stimulants and fresh air: these are the factors upon which we rely for assisting Nature in the great battle against tubercle. But the lung trouble is only evidence of one organ being infected. A general infection of the whole body may ensue; then other signs will appear, notably those of meningitis due to infection, with tubercle bacilli of the meninges or membranes of the brain.

It is, however, unnecessary to follow out this hopeless picture.

What should be remembered is the possibility of a simple cold developing into a fatal illness by reason of neglect. Dirtiness and untidiness in the house may similarly be a contributing cause. There should be no dusty corners. This fault can be obviated in the construction of dwelling-houses by rounding off all corners. In the model dwellings now being erected under the supervision of the London County Council, I am glad to note that this point is observed.

Pneumonia, lobar pneumonia, or inflammation of the lungs is a disease differing entirely from broncho-pneumonia, not only in its pathological effects upon the lungs, but also in its onset and course.

For, instead of many patches of inflammation throughout the lungs, one whole lobe becomes inflamed, and in place of a long-drawn-out illness, with varying phases of intensity, pneumonia runs a peculiarly constant and definite course, which begins suddenly, and culminates in a climax or crisis at the end of seven or eight days. It is caused by a specific organism—the pneumococcus. The onset is sudden, usually accompanied by vomiting; the temperature is raised to 102° or 103° F.; the face is flushed at first, and later shows a peculiar coloration in the cheeks. This colour approximates to the healthy blush of a healthy child, but yet on looking closely into its depths one sees it to be duller, dusky, or even somewhat blue. It is difficult to describe, but it is quite characteristic, and when once seen is easily remembered. There is sweating of the whole body, the breathing is short and quick, and the working of the nostrils is particularly noticeable. Cough is present, which at first is not very distressing. The illness runs its course for about one week, the temperature remaining at practically the same level throughout; the patient becomes more and more ill, in great distress from the rapidity of breathing from the cough, which becomes more and more troublesome, and from absence of sleep. Then comes a dramatic change. The crisis of the illness arrives; the temperature falls in a few hours to normal, there is profuse sweating, the child loses its apathy and looks bright and intelligent once more; appetite returns, it takes food readily, and sleeps for some hours at a time quite naturally; the cough becomes loose and no longer distresses the child—in short, from being apparently in the direst straits, in a few hours' time it is a different being, and well on the road to convalescence.

The regularity with which this chain of symptoms manifests itself in pneumonia is typical of the specific fevers, measles, scarlet fever, and typhoid fever, &c., and for this reason one should place pneumonia in this group; being, however, a lung affection, it is well to consider it at the same time as other diseases of the air-passages.

The above picture represents a case that ends satisfactorily, and it should be noted that the temperature is somewhat high. A point to remember in this connection is that a high temperature is not necessarily a bad sign, nor, on the other hand, is a low temperature necessarily of good omen. There is no rule that has not its exception, but in pneumonia it may generally be assumed that a case that shows a temperature of 103° to 104° F. is more likely to end favourably than one in which the temperature does not rise above 99° F. The reason for this is clear. A big rise in temperature denotes a big reaction on the part of the whole organism to the infection. Its powers are high relative to the dose of poison entering the system. Conversely a small rise shows a feeble reaction. Whether because of feeble power or intensity of poison it matters not; the result is the same, and the outlook is serious. The importance of this cannot be exaggerated. There is no medicine which will cure this disease. The organism has to fight its own battle, and it is only by careful nursing and stimulating treatment that we can assist Nature to win.

What has been said in regard to treatment and feeding in broncho-pneumonia applies equally here. With regard to steam, I prefer to use it as little as possible; but often the cough is dry, and the child cannot sleep until steam is given. There must be extreme care in handling the patient, for the heart is considerably weakened by the continuously high temperature, and a sudden sitting up of the child may induce a fatal attack of syncope—that is to say, stoppage of the heart's action. Oxygen and stimulants are required to be given freely, especially towards the end of the week, when the crisis may be expected. The sweating necessitates frequent changes of the bed-gown; there should always be a dry garment ready to replace the soiled or wet one.

It frequently happens that the temperature rises above 104° to 105° or even 106° F. Is one justified in saying that this is a good temperature and in leaving it untreated? By no means. The temperature should not be allowed to remain long above 103·5° F. In cases where these high temperatures are recorded tepid sponging must be resorted to.

To do this the child must be stripped and laid in a blanket with a mackintosh sheet or bath towel underneath to protect the bed. With water that just feels warm to the hand—that is, at a temperature of 100° F.—the face and neck should be gently and slowly sponged; after these in succession each arm, the chest, the body and legs should be similarly treated, each part being covered with the blanket as soon as the sponging is completed.

The time taken over the operation should be about twenty minutes, by which time the temperature will be found to have fallen 2 or 3 degrees. The thermometer should be placed in the rectum, as the temperature at the surface of the body will be considerably below that of the internal organs. The patient should now be redressed in a warm dry gown and put back to bed, when it will be found to sleep comfortably and easily for some considerable time. A word of caution is necessary, as it sometimes happens that the patient shows some signs of collapse, and if the cooling down process has been carried too far there may be difficulty in getting the feet warm. Brandy should be administered in case of collapse, and a hot bottle should be tucked into the blanket near the feet.

In the case of small infants it is more satisfactory to dip them in a bath at a temperature of 100° F. A good nurse can easily support the infant on one hand and arm in the bath, and can add cold water to the bath little by little until the temperature of this is reduced to 90° F. Where the infant is small and easily handled, an immersion of from five to ten minutes in this manner is far preferable, in capable hands, to a tepid sponging.

Pleurisy is the term used to denote inflammation of the pleura—the lining membrane of the lung and chest wall. This inflammation may occur independently of pneumonia, but pneumonia is seldom present without some co-existing pleurisy. It will be remembered that the freedom of movement of the lungs in the chest wall is due to the smooth and shining surfaces of the pleura. When these are inflamed the surfaces are rough and tender; movement causes acute pain, consequently the respiratory movements of the chest wall are very limited, hence the breathing is short and rapid. The inflammation of the pleura may quickly subside, or fluid may be exuded from the inflamed surfaces into the space between, which may be either clear serum or become purulent. It is especially in children that this purulent effusion occurs as a complication of pneumonia. Empyema is the name for this condition. It may be looked upon as an abscess inside the chest wall, and should be evacuated by an opening in this wall.

When a pneumonia fails to clear up, or after the crisis the temperature does not subside, but takes on a remittent type, low in the morning and high in the evening, an empyema should be suspected. It is, however, outside the scope of this work to continue the complication of pneumonia.

The details of feeding and treatment of the infant in health and disease have been sufficiently discussed to enable a nurse or mother to handle and care for her child. The standard text-books should be consulted for further details.

APPENDIX I

Whilst it is true that raw cow's milk is protected by good organisms against the development of the putrefaction or dirt organisms, and is therefore far safer as an infant food than milk that has been boiled or so-called sterilized; yet it, of course, should be our principal interest for the welfare of the infant to see that all contamination of the milk with poisonous organisms should be rendered almost impossible.

What, then, should be our ideals for this purpose?

Anyone acquainted with country districts will know that at every turn milk is liable to contamination.

The milkman is usually seen milking the cows wearing manure-sodden clothes with hands that are anything but clean. The cows, more often than not, show masses of dried manure on their hides and at the end of the tail. This latter being constantly in motion to flick off flies, naturally causes the dried manure to be brushed off into the milk-pail below. The milking shed is usually the same as for sleeping purposes; the straw may be thrown up under the manger, but is frequently seen still lying under the cows soiled from the previous night. The roof of the shed is full of cobwebs; dust abounds in every corner, and there may be hay in the racks, or, as well, stored on hurdles above the cows. Could it, then, be expected that milk can be anything but dirty when collected under such unfavourable conditions?

Such an important article of food as milk should be protected as carefully as the surgeon's hands before an operation; the arrangements in the milking shed should be as strictly aseptic as exist in a modern operating theatre. Here the walls are so constructed as to leave no corners or chinks where dust can collect. The floor is cemented; there is no wainscot; nor is there any angle between the walls and the floor, or the walls and ceiling. This angle is filled up and replaced by a rounded moulding of cement. The surface of the walls and ceiling are glazed with some resistant paint, and the floor is constantly washed over to remove any dust. It may be urged that such a state of perfection cannot be acquired by a small dairyman. Certainly it is a big expense as an initial outlay, but considering the importance of pure milk this argument should not be allowed to stand. It is a high ideal to have a milking shed constructed on the lines of an operating theatre, but yet a separate shed for milking purposes only should be compulsorily part of the equipment of every dairyman, and in the construction of this the principle of no corners or chinks for the harbouring of dust, cement floors, and smooth walls should be observed. Indeed, this principle is made use of in the construction of model dwellings at the present time, and therefore it might easily be extended to the milking shed. There should be a good supply of water, so that every day before the milking the whole shed can be thoroughly sprayed with water. The drainage must be good to allow of this water running quickly away. Before entering the milking shed the cow should be brushed down, the tail should be cleaned and wrapped in a special wrapper, and the teats should be cleansed with soap and water.

The milkman should next cleanse his own hands with at least two washings of soap and water, and should then put on a clean overall. He may now follow his cow into the shed with a pail that has been sterilized by boiling water or nascent steam, and which is provided with a well-fitting cover. His milking-stool should have been cleansed when the shed was sprayed. He will next remove the cover from the pail and proceed to milk his cow; when this is completed, he will cover the pail and remove the milk to the cooling chamber. Having finished his milking, he should see that his overall is washed and boiled ready for the next milking.

We now come to the second important point in the preservation of cow's milk—namely, the cooling of it. We know that all bacteria are inhibited in their growth by cold. If, then, milk is cooled down to a point at which bacteria will not grow, it is virtually sterile and will not turn sour, provided the temperature does not rise under at least seventy-two hours—that is, it will keep three days. But it is everyone's experience that in the summer months milk turns sour in a few hours. The reason for this is that, in the first place, the milk is cooled only by means of cold tap water, and the temperature of this is, of course, high in the warm months of the year, and in the second place there is no attempt at keeping the milk cold during its transit from the dairy to the consumer. Now we know that under favourable conditions of temperature, such as summer temperature, the acid organisms are at their maximum output in eight hours. Consequently these organisms grow rapidly in the milk during the summer months, and as a result much acid is produced which causes the milk to turn sour in eight to ten hours. The cleaner our milk, the more readily will it sour if we do not arrange for the milk to be maintained at a temperature sufficiently low to inhibit the growth of these organisms. This temperature should be 40° F., which, of course, is but a few degrees above freezing point. It is clear, then, that there should be a refrigerating plant attached to every dairy in order to cool down the milk rapidly to this temperature.

But a refrigerating plant is an additional expense to the producer, which naturally will fall wholly or in part upon the consumer. How can this be obviated?

I think quite easily if the principle of co-operation were introduced into our agricultural districts. The county should be divided into districts; each district should have a central depôt for receiving milk, and here there should be a refrigerating plant capable of cooling large quantities of milk, and from this central depôt the cooled milk could be despatched to its destination. Milk should arrive at each centre within one or two hours of the time it was drawn, no time having been taken up in cooling at the dairy. It will then be seen that each central depôt would be a clearing-house for milk, and it would enormously add to the welfare of the nation if, in addition, a laboratory were established at each depot with a competent bacteriologist and analyst to examine the various milks on arrival, and the resulting milk before its departure.

The third consideration of our milk supply is its mode of transit to its destination. Knowing the importance of keeping milk at a temperature of 40° F., it is perfectly plain that the existing state of affairs should be at once altered. It is probably everyone's experience at one time or another to have had the misfortune to travel by a "milk" train—that is to say, a train which stops at every station and takes in a varying number of milk churns at each. These churns have been waiting on a hot platform for some hours it may be, and are then placed in an exceedingly hot milk truck, in which there is no apparatus for maintaining a low temperature. Two methods suggest themselves to obviate this difficulty. The first is to construct milk vans with a refrigerating plant, or, on the other hand, to construct churns that are insulated from the outside air; in other words, the churns should be really large thermos flasks. The principle involved in the construction of a thermos flask, as everyone knows, is that the flask shall be surrounded by a hollow jacket from which the air has been extracted, or, in other words, where a vacuum is created. Churns constructed on this principle are in use for the supply of milk to The Infants Hospital. The result is that the temperature of the milk on arrival at its destination is practically the same as when it was despatched from the cooling chamber at the farm.

Finally, we have to consider the distribution of milk when it has arrived in churns at the milk shop or dairyman's premises. Most of us are familiar with the usual methods employed to bring our milk to our own doors. To the regular customers it is sent out for the most part in sealed bottles. But a large amount is sent out to irregular customers in an ordinary milking pail, from which a none too clean serving man or woman dips a metal measure, which is fitted with a handle to fit on the rim of the pail. The same measure is used throughout the whole of the delivery, and there is no provision for cleansing it from dust or mud that may bespatter it, or from other impurities gained by contact with the distributor's clothes and hands. This method of distribution should be absolutely forbidden, as also dipping into a vessel inside the shop for the chance customer. For consider again the method here employed. A large open vessel is placed in a prominent position upon the counter in the shop. There may or may not be a cover provided for this vessel. If there is, it is usually not in position. For serving customers there is again a metal measure which hangs inside the vessel by means of its handle, and which is used to dip into the milk. After use it is frequently placed on the counter and again used for the next customer without any effort at cleansing. The milk is thus exposed to the heat of the shop, to the dust raised by the tread of customers, and to contamination by flies and other insects, and by the hands of the server; there is nothing left undone which can contaminate it.

This open method of distributing milk should be absolutely forbidden.

To obviate handling the milk, upon arrival in the churn it should be poured out into a specially constructed tank. This tank should be in a special milk room, where the temperature is kept low either by a refrigerating plant, or simply by means of blocks of ice. The tank should have a close-fitting lid, and a tap so constructed as to be capable of being taken to pieces and thoroughly cleansed. From this tank the bottles can be readily filled through the tap, and at once sealed. They should then be left in this milk room ready for delivery. For the shop or outside delivery there should be a small churn, constructed with a vacuum jacket, and fitted with a tap similar to the one in the tank. This churn should be suspended on a light frame by two supports fixed about the middle, so as to allow of the churn being revolved or turned over. This would prevent an unequal supply of cream in the milk; for an occasional revolution of the churn would effectually mix the milk, and so check the cream from rising to the surface. All that would be necessary to supply the milk to the customer would be to turn on the tap into a pewter measure with a hinged lid. The tank, bottles, churns and measures should, of course, be cleansed thoroughly with boiling water or nascent steam after use.

It is not only up to the time of its arrival at our doors that we have to take care of our milk; there are still a few important points to observe after we have received it. It should be carefully covered up and placed in the coolest spot possible. An ice-chest is, of course, the best place in which to keep it, but it is not everyone who possesses an ice-chest. A mistake often made in the effort to keep milk cool is to stand it in a jug which is placed in a basin of cold water. This water, of course, in the summer months is at summer temperature, which we have seen is the best temperature for all organisms to grow in. We want a much colder temperature than this, and this can be produced by evaporation. If the jug or vessel containing the milk is wrapped in a thick towel which has previously been wrung out of cold water, evaporation at the surface will produce a considerable degree of cooling in the milk within. By this simple method the milk is kept cool, and at the same time is protected from contamination with dust and flies, &c.

APPENDIX II

It may be of advantage to have a list of milk mixtures in front of us, and for this I append some. The intelligent reader will learn from these how simple a matter it is to obtain any modification of milk until it is exactly suited to the particular infant. The percentage composition is estimated, taking the percentage of cow's milk to be:—

Fat	4·00 per cent.
Whey proteins	1·00 ,,
Caseinogen	2·75 ,,

In these specimen feeds it is understood that water as diluent means lactose water, *i.e.*, water in which lactose or sugar of milk has been dissolved in the proportion of one tablespoonful of lactose to one pint of boiled water, and to which has been added two tablespoonfuls of lime water.

These various modifications of cow's milk have been in use for many years in the out-patient department of The Infants Hospital, and have proved extraordinarily successful considering the unequal supply of milk and its extremely uncertain composition. For repeated examinations of milk will show the fat content as cream to be as low as 3 per cent., or as high as 4 per cent. And again, the percentage of this cream in actual fat may vary enormously from 16 per cent. to 60 per cent.

Yet, in spite of this uncertainty, the results are wonderfully satisfactory, and reflect great credit upon the mothers who so willingly co-operate for their infants' welfare.

There are two methods of preparing the feeds :—

(*a*) Each feed is made up separately from the milk, fat whey, and lactose water.

(*b*) An amount sufficient for twelve to twenty-four hours is made at one time.

Of the two methods (*a*) is to be preferred if there is any difficulty in keeping the milk; (*b*) from the point of view of accuracy of the constituents, a much finer graduation of these being obtainable.

A.

Suitable up to Three Months of Age.

Fat whey	5 parts	=	Fat	$\frac{5+1}{10}$	×	4·00	=	2·40 per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{6}{10}$	×	1·00	=	0·60 ,,
Water ...	4 ,,	=	Caseinogen ...	$\frac{1}{10}$	×	2·75	=	0·27 ,,
	10 parts							

Fat whey	4 parts	=	Fat	$\frac{4+1}{10}$	×	4·00	=	2·00 per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{5}{10}$	×	1·00	=	0·50 ,,
Water ...	5 ,,	=	Caseinogen ...	$\frac{1}{10}$	×	2·75	=	0·27 ,,
	10 parts							

Fat whey	3 parts	=	Fat	$\frac{3+1}{9}$	×	4·00	=	1·80 per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{4}{9}$	×	1·00	=	0·44 ,,
Water ...	5 ,,	=	Caseinogen ...	$\frac{1}{9}$	×	2·75	=	0·30 ,,
	9 parts							

Fat whey	3 parts	=	Fat	$\frac{3+1}{8}$	×	4·00	=	2·00 per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{4}{8}$	×	1·00	=	0·50 ,,
Water ...	4 ,,	=	Caseinogen ...	$\frac{1}{8}$	×	2·75	=	0·34 ,,
	8 parts							

Fat whey	4 parts	=	Fat	$\frac{4+1}{8}$	×	4·00	=	2·50 per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{5}{8}$	×	1·00	=	0·62 ,,
Water ...	3 ,,	=	Caseinogen ...	$\frac{1}{8}$	×	2·75	=	0·34 ,,
	8 parts							

Fat whey	4 parts	=	Fat	$\frac{4+1}{7}$	× 4·00	= 2·86	per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{5}{7}$	× 1·00	= 0·71	,,
Water ...	2 ,,	=	Caseinogen ...	$\frac{1}{7}$	× 2·75	= 0·40	,,
	7 parts						

Fat whey	4 parts	=	Fat	$\frac{4+1}{6}$	× 4·00	= 3·33	per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{5}{6}$	× 1·00	= 0·83	,,
Water ...	1 ,,	=	Caseinogen ...	$\frac{1}{6}$	× 2·75	= 0·45	,,
	6 parts						

Suitable from Three to Five Months of Age.

Fat whey	3 parts	=	Fat	$\frac{3+1}{5}$	× 4·00	= 3·20	per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{4}{5}$	× 1·00	= 0·80	,,
Water ...	1 ,,	=	Caseinogen ...	$\frac{1}{5}$	× 2·75	= 0·55	,,
	5 parts						

Fat whey	2 parts	=	Fat	$\frac{2+1}{4}$	× 4·00	= 3·00	per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{3}{4}$	× 1·00	= 0·75	,,
Water ...	1 ,,	=	Caseinogen ...	$\frac{1}{4}$	× 2·75	= 0·69	,,
	4 parts						

Fat whey	1 part	=	Fat	$\frac{1+1}{3}$	× 4·00	= 2·63	per cent.
Milk ...	1 ,,	=	Whey proteins	$\frac{2}{3}$	× 1·00	= 0·66	,,
Water ...	1 ,,	=	Caseinogen ...	$\frac{1}{3}$	× 2·75	= 0·90	,,
	3 parts						

Fat whey	1 part	=	Fat	$\frac{2}{2}$	× 4·00	= 4·00	per cent.
Milk ...	1 ,,		Fat whey ...	$\frac{2}{2}$	× 1·00	= 1·00	,,
			Caseinogen ...	$\frac{1}{2}$	× 2·75	= 1·37	,,
	2 parts						

Suitable from Six to Nine Months of Age.

Fat whey	3 parts	=	Fat			4·00	per cent.
Milk ...	2 ,,		Fat whey			1·00	,,
			Caseinogen ...	$\frac{2}{5}$	× 2·75	= 1·10	,,
	5 parts						

$$\left.\begin{array}{ll}\text{Fat whey} & 2 \text{ parts}\\ \text{Milk} \ldots & 1 \;\;,,\end{array}\right\} = \left\{\begin{array}{lll}\text{Fat} \ldots \ldots & \ldots & 4·00 \text{ per cent.}\\ \text{Fat whey} \ldots & \ldots & 1·00 \;\;,,\\ \text{Caseinogen} \ldots & \frac{1}{3} \times 2·75 = & 0·90 \;\;,,\end{array}\right.$$

3 parts

$$\left.\begin{array}{ll}\text{Fat whey} & 3 \text{ parts}\\ \text{Milk} \ldots & 1 \;\;,,\end{array}\right\} = \left\{\begin{array}{lll}\text{Fat} \ldots \ldots & \ldots & 4·00 \text{ per cent.}\\ \text{Fat whey} \ldots & \ldots & 1·00 \;\;,,\\ \text{Caseinogen} \ldots & \frac{1}{4} \times 2·75 = & 0·69 \;\;,,\end{array}\right.$$

4 parts

B.

$$\left.\begin{array}{ll}\text{Fat whey} & 2 \text{ parts}\\ \text{Milk} \ldots & 1 \;\;,,\\ \text{Water} \ldots & 1 \;\;,,\end{array}\right\} \quad 40 \text{ oz.} = \quad \left\{\begin{array}{l}20 \text{ oz. fat whey}\\ 10 \;\;,, \text{ milk}\\ 10 \;\;,, \text{ sugar water}\end{array}\right.$$

or,

40 oz. can be :—

18 oz. whey ... Fat ... ... $\frac{9+6}{20} = \frac{15}{20} \times 4·00 = 3·00$ per cent.
12 ,, milk ... Fat whey ... $\frac{9+6}{20} = \frac{3}{4} \times 1·00 = 0·75$,,
10 ,, water ... Caseinogen ... ... $\frac{5}{20} \times 2·75 = 0·69$,,

or,

18 oz. whey ... Fat ... ... $\frac{29}{40} \times 4·00 = 2·90$ per cent.
11 ,, milk ... Fat whey ... ... $\frac{29}{40} \times 1·00 = 0·72$,,
11 ,, water ... Caseinogen ... ... $\frac{11}{40} \times 2·75 = 0·75$,,

or,

18 oz. whey ... Fat ... ... $\frac{31}{40} \times 4·00 = 3·10$ per cent.
13 ,, milk ... Fat whey ... ... $\frac{31}{40} \times 1·00 = 0·80$,, *nearly*
9 ,, water ... Caseinogen ... ... $\frac{13}{40} \times 2·75 = 0·89$ per cent. *nearly*

or,

16 oz. whey ... Fat ... ... $\frac{26}{40} \times 4·00 = 2·60$ per cent.
10 ,, milk ... Fat whey ... ... $\frac{26}{40} \times 1·00 = 0·65$,,
14 ,, water ... Caseinogen ... ... $\frac{10}{40} \times 2·75 = 0·69$,,

And so on. Any variation can be made according to the infant's powers of digestion of fat and caseinogen.

$$\text{Saline lactose} = \left\}\begin{array}{l}\text{Table salt, one teaspoonful.}\\ \text{Sugar water, one pint.}\end{array}\right.$$

Albumen water = The white of one raw egg, whipped up in half a pint of cold boiled water.

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